2013 INTER-SESSIONAL MEETING OF THE TROPICAL TUNA SPECIES GROUP

(Tenerife, Spain - March 18 to 21, 2013)

SUMMARY

The Intersessional Meeting of the Tropical Tuna Species Group was held in Tenerife, Spain, 18-21 March 2013. The objective of this meeting was to establish the TORs to design the Atlantic Ocean Tropical Tagging Program (AOTTP).

RÉSUMÉ

La Réunion intersession du Groupe d'espèces sur les thonidés tropicaux a eu lieu à Tenerife (Espagne) du 18 au 21 mars 2013. L'objectif de cette réunion consistait à définir les termes de référence de la conception d'un programme exhaustif de marquage de thonidés tropicaux.

RESUMEN

La Reunión intersesiones del Grupo de especies de túnidos tropicales se celebró en Tenerife, España, del 18 al 21 de marzo de 2013. El objetivo de la reunión era establecer los términos de referencia para el diseño de un gran programa de marcado de túnidos tropicales.

1. Opening, adoption of Agenda and meeting arrangements

The Meeting was held at the *Centro Oceanografico de Canarias* of the *Instituto Español de Oceanografía* (IEO), in Tenerife from March 18 to 21. Dr. Pilar Pallarés, Assistant Executive Secretary of ICCAT, opened the meeting. Dr. Pallarés welcomed participants and thanked the IEO for hosting the meeting and providing the Group with all the logistic arrangements of the excellent new Center in Canary Islands. Dr. Joao Pereira, General Rapporteur of Tropical Tunas Species Groups, chaired the meeting.

The Agenda (**Appendix 1**) was adopted with some changes. The List of Participants is included in **Appendix 2**. The List of Documents presented at the meeting is attached as **Appendix 3**.

Dr. Pereira reminded the Tropical Tunas Species Group (hereafter "The Group") that the objective of the meeting was defined in the 2012 Work Plan for Tropical Species approved by the SCRS (ICCAT, 2013a).

The following participants served as rapporteurs:

P. Pallarés	Items 1, 6 and 7
D. Die, C. Brown, J.P. Hallier, J. Million, A. Fonteneau	Item 2
G. Scott, D. Gaertner	Item 3
J. Santiago	Item 4
J. Pereira	Item 5

2. Revision and update of the AOTTP prepared in 2010

2.1 Summary of the development of the AOTTP program

Compared to the Pacific and to the Indian Ocean, the tagging effort in the Atlantic Ocean has been very low. Some key biological parameters that are required to support stock assessments are missing or poorly known and the recent level of exploitation of the three tropical tuna species remains uncertain. Therefore, in 2010, the SCRS proposed an Atlantic Ocean Tropical Tuna Tagging Program (AOTTP). This new program is intended to cover the whole Atlantic Ocean and with a funding level comparable to the large-scale tuna tagging projects of the Pacific and Indian Oceans. At the 2012 SCRS it was decided that to accelerate the development of this proposal the Tropical Tunas Species Group would examine lessons from the Indian Ocean Tuna Tagging Program (IOTTP), develop specific objectives for the AOTTP and identify, if necessary, terms of reference for a contract in support of the development of the AOTTP. In early 2013, the Tropical Tunas Species Group agreed to invite and fund the participation of Indian Ocean Tuna Tagging Program experts to this inter-sessional meeting. These two experts, Julien Million and Jean Pierre Hallier, presented in detail the lessons learned from the IOTTP and participated in the discussions of the Group.

2.2 Results and lessons from the IOTTP

The Group was informed of the main results from the IOTTP (IOTC, 2012) implemented from 2002 to 2009 and the different aspects that should be taken into account for the development of a similar large-scale tuna tagging program in the Atlantic Ocean. This program was a combination of a large-scale project, the Regional Tuna Tagging Project in the Indian Ocean (RTTP-IO), funded by the DG-Development of the European Union (14 million Euros) and several small-scale operations (Maldives, Indonesia, Mayotte, India, etc.) funded by the DG-Maritime Affairs and Fisheries of the European Union and the Government of Japan. The Indian Ocean Tuna Commission (IOTC) was in charge of the supervision of the RTTP-IO and the implementation of the small-scale operations.

During the IOTTP, more than 200,000 tropical tunas were tagged and released, mainly in the western Indian Ocean and so far, more than 32,000, or 16%, have been recovered and reported. The program showed that while the costs involved in small-scale operations in the Indian Ocean were lower than the large-scale operation (around 35€/tagged fish vs. 85€/tagged fish), the quality of the tagging and recovery information was not as good, and therefore as of today the data obtained from small-scale operation are of limited use for supporting stock assessments. This highlights the fact that the success of tagging programs should be measured not solely by the number of tagged fish, or the average cost per tagged fish, it should also consider the number of recaptures obtained with useful information and the cost of obtaining these.

The general and specific objectives of the IOTTP were achieved and today, tagging data are routinely used in stock assessment at the IOTC. Analyses of the data have showed new complex growth patterns for yellowfin and bigeye, very different from the previously used von Bertalanffy growth curves, and a lower level of natural mortality. Fast and long-range movements of the three species of tropical tunas in the Indian Ocean were documented. Tuna were reported to travel over 700 nm in short periods of times of less than 1 month.

The following is a list of lessons from the IOTTP that should be taken into account when designing the AOTTP:

- Objectives should be clearly defined.
- The structure, scale and duration of the program should be adapted to these objectives.
- Rules and procedures attached to the funding (e.g., European Development Fund) should be well understood and dealt with in the design phase.
- The timing of the different contracts (i.e., technical assistance, chartered vessel, equipment, etc.) should be well planned.
- Staffing of the program, for both the tagging and recovery phase.
- Access agreement/fishing permits should be requested in advance of the start of the tagging.
- Tagging and recovery procedures should be well defined.
- Publicity and recovery plan should start as soon as the tagging starts, or even before.
- Databases, both for tagging and recovery, should be developed centralized at the ICCAT Secretariat.
- Procedures to link recovery data with logbook data, in particular for purse seine recoveries, should be well defined.
- Tag seeding activities should be implemented throughout the whole duration of the project onboard vessels in the purse seine fishery, as well as other activities to be able to estimate the reporting rate for other fisheries (i.e., longline).

The Group acknowledged the excellent results of the IOTTP, and noted that while releases might have been slightly concentrated in some parts of the western Indian Ocean, the different objectives of the project have been achieved. This was partly due to the Associated School Fishing Technique implemented off the coast of Tanzania, a method developed in the Atlantic Ocean and now routinely used by several fisheries in West Africa, Canaries, Acores, etc.

The Group agreed that the general objective of the AOTTP is similar to that of the RTTP-IO. Therefore, the experience from the IOTTP, particularly the large-scale of the RTTP-IO, would be very useful for the definition of the project and a feasibility study. The Group recognized that the administrative burden of this project on the ICCAT Secretariat would be greatly increased and that it will probably require some support, through or outside of the project. The Group also noted that several potential donors could be approached and that a variety of funding could offer better flexibility and ensure effective utilization of the funds.

Additional conclusions reached by the IOTTP that are particularly relevant to the development of the AOTTP are:

- Tag shedding rates are readily quantifiable from double tagging studies.
- Fish tagged from pole and line vessels are recaptured by the tagging vessel. However, such fish can be released alive when in good condition and rejoin the tagged portion of the stock. Some of these fish were recaptured many times.
- Deployment of fish tagged with satellite tags was not very successful in the IOTTP. However, technology has since improved. Recent experiences in the Gulf of Mexico and previous studies in the Pacific with yellowfin tuna indicate that electronic tags are a feasible option for tropical tunas.
- The comparison of the success of the large- and small-scale components of the IOTTP suggests that it may be better to focus the AOTTP on a subset of fishing fleets for which it is possible to estimate either tag reporting rates and/or ensure a high tag reporting rate.
- The AOTTP should seek the cooperation of countries that have observer programs on board vessels in the area of the ICCAT Convention and invest in ensuring these observers have the right incentives and resources to report tagged fish.
- Seeding experiments to estimate tag reporting rates can be effectively conducted in purse seine vessels, but methods to conduct them in other fleets need to be developed.
- High reward tags commonly used to estimate reporting rates in other fisheries may face problems in fleets where high rewards can create disputes between boat owners, skippers and crew.
- Data generated from such a tagging project should be made public after appropriate provision has been made to eliminate confidential data and the program team has had a reasonable chance to capitalize on their efforts through the production of scientific papers.
- Management of funds provided by the EU is subject to specific constraints and rules that create a significant administrative overhead. The cost of such management should be considered in the design of the AOTTP.
- A feasibility study needs to be conducted as part of the development of the AOTTP. This study needs to investigate all the aspects of the program: administrative, legal, financial and scientific.
- The initial draft of the AOTTP proposal should provide different optional scales at which the program can be implemented. The feasibility study needs to evaluate these options.
- Costs of chartering the pole and line vessels are linked to the opportunity costs of the available vessels which are strongly related to the future prize of pole and line caught tuna.

2.3 Review of objectives and priorities for the AOTTP

The Group used the objectives presented in the 2012 SCRS Report (ICCAT, 2013) as a starting point for the discussions (**Table 1**).

The Group then decided that the AOTTP program should be described as having an overall goal to improve sustainability of tropical tuna resources by providing the best science available to ICCAT (Res. 11-17). This goal will be achieved through the following four objectives:

- Estimating the recent exploitation rates of tropical tuna.
- Determining the extent of interaction between surface and longline fisheries.
- Evaluating the effectiveness of management measures (e.g., time area closures, FAD management, etc.)
- Increasing the capacity for assessment of tropical tunas in the African, Caribbean and Pacific Group of States (ACP) countries.

In order to achieve these goals, the Tropical Tunas Species Group defined a series of specific operational objectives for the program. These objectives were then prioritized by the Group to facilitate the development of the AOTTP. Prioritization was accomplished by grading objectives according to two criteria: the potential benefits provided to stock assessment of tropical tuna, and the feasibility of reaching the objective with the AOTTP. Overall priority was set equal to the lowest of the two ratings assigned. Objectives and corresponding priorities show that (**Table 2**) the highest priorities of this program should be to confirm current assumptions about stock structure of tropical tuna, to estimate area-specific and fleet-specific recent fishing mortality independently of CPUE data, and to estimate age-specific and area-specific tropical tuna growth rates. Additionally important objectives are to estimate age-specific natural mortality and to contribute to the stock assessment for two small tuna species, Atlantic bonito and Atlantic blackfin tuna.

The Group also discussed the best strategy to implement the AOTTP, including the possible sources of funding to support it. After discussion, the Group agreed on a series of actions that need to be achieved to ensure the continued development of the program. It also identified some key groups and individuals that would be responsible to achieve these actions and some possible funding sources to support the different stages of the AOTTP (**Figure 1**).

The Group agreed to the development of terms of reference for a new coordinator for the AOTTP Task Force. This new coordinator will help the AOTTP Task Force accomplish the first steps in the development of the AOTTP (**Table 3**).

The Group agreed that the existing AOTTP Task Force, made up of members from the Tropical Tunas Species Group, needs to identify and communicate with key collaborators in agencies that are potential candidates for funding the two main components of the program, (e.g., DG-MARE and DG-DEVCO, USA, Asian countries members of ICCAT). Details of initial approaches made by the Group to potential funding agencies are provided in **Appendix 4.** Similarly the AOTTP Task Force needs to identify key collaborators in some of the ACP countries so that these collaborators can facilitate the request of letters of support from the government of these countries. The first output from the task force will be a proposal for a feasibility study to support the design of the AOTTP. Given the outputs provided by the feasibility study, the AOTTP task force will develop a second proposal, this one for the implementation of the AOTTP. The proposals for the feasibility study and the AOTTP program may have to proceed together to ensure funding success.

2.4 Development of the Scientific Design of the Tagging Program

An essential component of the feasibility study will be the development of a detailed, realistic scientific design for the program, which will be critical for the evaluation of the operational requirements and costs. NOTE: The framework for this scientific design presented here reflects the discussions of the Group; the AOTTP Task Force may further expand and refine this framework. In general, this design should address the objectives and priorities that are defined by the SCRS, providing an operational plan on how these can be achieved. Estimates should be produced on the precision of the various estimates for different levels of tagging effort, as well as recommendations on optimal numbers, deployment strategies (e.g., gear, time, area) and mix of tags (i.e., conventional, archival – pop-up and internal). Tag deployment strategies and efforts to optimize the recapture and reporting rates should be designed to reflect the total range (both time and area) of the species.

The study should be designed to achieve (or include) the following essential elements:

- A standardization of tagging operations (training/skill of taggers, vessels, etc.).
- Accurate, precise estimates of tagging related mortality, tag shedding, fleet-specific reporting rates.
- Public outreach optimizing the reporting of recaptured tags, with complete information, and the return of recovered archival tags.
- Contingency plans to ensure coverage of fishing grounds not accessible or otherwise unsuitable for the standard tagging operations.

As previously indicated, the AOTTP Task Force may identify additional essential elements.

This design should take into account the logistics involved in carrying out the recommended strategies. For example, although baitboats may generally be the best platform for large-scale tag deployments, baitboat operations are limited by the availability of bait. For some regions, it may be necessary to consider alternatives (e.g., recreational vessels, suitable commercial vessels). Similarly, oceanographic conditions or fish behavior could impact accessibility or catchability in certain areas; such considerations should be taken into account.

For many areas, the predominant fisheries may be those which typically exhibit low reporting rates (e.g., longline). Therefore, public outreach and publicity, including ongoing direct contact with vessel captains, is an extremely important element.

Additionally, pop-up satellite archival tags (PSATs) can play an important role, especially given the low reporting rates expected from many fisheries. Recovery and reporting by a fishing vessel is not necessary in order to obtain such data; these tags transmit summary data (including swimming depth, water temperature, and location estimates) after detaching from the fish. This can provide critical information on tagging mortality, migration rates and stock mixing patterns. Internal archival tags can also collect these data, avoiding potential attachment difficulties, but rely on fisheries for recovery and return. Archival data (pop-up or internal) can also provide the data necessary to identify preferred habitat profiles, as well as important behaviors, which are extremely useful for the interpretation and standardization of abundance indices and fishery trends, and may be essential for future ecosystem-based assessments.

An important underlying principle for this study is that the data collected through activities funded through this program will be made available to ICCAT scientists. This includes electronic archival tag data at the most detailed level of resolution.

As an example of the role that simulation modeling can play in the design of the study, a general capture-recapture tagging model was developed in advance of the meeting and was presented to the Group (SCRS/2013/031). This statistical framework, which can be used for estimating stock mixing, natural mortality and fishing mortality rates, could be applied to a broad range of Atlantic migratory species and adapted to meet various study objectives. The Group commented that the model simulation results seemed optimistic given the simulated sample sizes in comparison to results from the IOTC program. It was noted that one reason for the lower predicted estimate variance compared to observed results from the IOTC was that the simulation applied to an individual cohort and that age-specific migration and region specific natural mortality rates would require a much greater tagging effort due to ageing error.

Additional discussion pointed out that the model approach was different from the IOTC results in that migration rates from electronic tags are incorporated as informative priors to avoid estimation of these rates with mortality rates. The Group also noted that the model should integrate type 2 tag loss (observed to be approximately 5% annually in the IOTC) which would also increase the predicted coefficient of variation of model estimates. The model is flexible in that it is adaptable to incorporate increased complexity (e.g., age-classes, multiple fleets, number of areas) and can utilize information from results of other studies, such as the IOTC tagging program or electronic archival studies, to further refine assumptions and input parameters. The Group considered that this model could be a useful tool for evaluating different hypotheses and the expected effect on parameter estimates under different tagging levels and strategies.

To illustrate the potential utility of electronic archival tagging as part of the overall program, an update on a U.S. program deploying PSATs on yellowfin tuna in the Gulf of Mexico was presented. Since August 2010, this program has deployed 55 PSATs on yellowfin ranging from 100 cm to 160 cm FL; about 80% of the tagged fish had estimated lengths ranging from 130 cm to 150 cm FL. Five (5) fish were caught using rod and reel gear, and brought aboard small vessels for tagging. The remainder was caught on longlines, and nearly all of these were tagged while in the water. Eleven (11) of the tags surfaced after less than 10 days, to a large extent a consequence of the difficulties encountered developing techniques for tagging from a longline vessel, 3 did not report and 4 are not yet scheduled to have reported. The remaining 37 tags tracked the movements of the fish, recording depth, temperature and light levels (for later estimation of location) every ten seconds for durations as long as 172 days, with a median deployment duration of 74 days (16 tags were recovered). Only 3 fish left the Gulf of Mexico, two in June and one in December. Interestingly, the two longest duration tags (155 and 172 days), show movements restricted to a relatively small area (< 300 km) along the edge of the continental shelf and the adjacent slope near the mouth of the Mississippi. An additional 30-35 tags are expected to be deployed on yellowfin in the Gulf of Mexico, including deployments conducted as part of a collaboration between Mexico and the United States to deploy PSATs in Mexican waters in the southwestern Gulf of Mexico.

The Group considered these preliminary results to be interesting, considering the large-scale movements that have been observed using conventional tags (**Figures 2-4**). It was noted that although conventional tag data confirm that yellowfin tuna move from the northwestern Atlantic and Gulf of Mexico to waters near Africa, many questions remain on frequency of those movements, the proportion of the stock involved, and the circumstances under which such movements take place. The preliminary results of this PSAT study provide support to the concept that yellowfin movement patterns are complex. This is not unexpected, but characterization of movements and migrations and quantification of rates is extremely lacking for tropical tuna species. The use of PSATs could provide important information; the Group considered that deployment of electronic tags across time and area strata may enable time-area specific rates to be calculated, even considering the deployment durations that have been achieved to date. If such a deployment across areas was possible it would also help in the estimation of movement rates across regions. It is often the lack of knowledge on these migration rates that makes it difficult to estimate natural mortality from tagging data. Thus, PSAT studies may also be a key for the estimation of natural mortality.

3. Revision and evaluation of Task II catch and effort and size data for the intermediate period considered by the Group

The Group briefly reviewed recommendations it made previously to guide the work of revision and evaluation of statistics by Task Force Ghana (TFG), first made in 2011. Among them were recommendations for improvements in data collection infrastructure and procedures to fully address data reporting obligations, recommendations for mechanisms for meeting data obligations, as well as technical recommendations for addressing the issues (ICCAT, 2012). While the Group noted that a number of these recommendations were being addressed both by TFG and the Ghanaian administration, presently, there appeared to be elevated concern related to adequate monitoring and control of the Ghanaian fleet possibly resulting in a reduction in market access for tuna caught by Ghana. Even though the Group noted this was mainly a compliance issue, it was suggested that further enhancement of monitoring of the fleet by adopting tools such as electronic observation on the fleet could well provide a sufficient means to validate fleet performance and meet data reporting obligations under the Convention. It was further noted that such a program was envisioned under the soon to be launched FAO/GEF ABNJ[1] program and the Group encouraged collaboration by the Ghanaian administration with that program. Additionally, Group noted that increases in the port sampling staff by the Marine Fisheries Research Division (MFRD) was now allowing improved data collection, but that logistical problems in support of data collection were still occurring, preventing optimal use of staff time and limiting access to vessels in port. It was recommended that increased logistical support was still needed to take full advantage of the available port sampling staff.

3.1 Review of current status of work conducted by the Working Group on the improvement of Ghanaian statistics

SCRS/2013/023 presented progress on the work undertaken related to the improvement on Ghana statistics by Task Force Ghana (TFG). The document described data, methods and hypotheses proposed to refine estimates of Task II (catch and effort and catch-at-size statistics) for the Ghanaian fleet during the period of 1996-2005. This work was carried out under the general guidance of the Tropical Tuna Species Group 2013 Work Plan and as proposed in SCRS/2012/041.

The Group reviewed the work undertaken by TFG, which it found to be of high quality. Upon review, the Group suggested that making maximum use of the available information from the Ghanaian fisheries rather than relying too heavily on the European fleet data as a substitute was a preferable approach to revision of the 1996-2005 Ghana Task II statistics. This approach was subsequently incorporated into the TFG work (so-called Hypothesis 3), which was adopted by the Group. Detailed information on the method followed to estimate the Task II statistics is included in **Appendix 5**.

Estimates of "faux poisson" landed by the Ghanaian fleet were also generated for the period 1996-2005 in SCRS/2013/023 based on samples collected in Abidjan during that period. The Group recommended adoption of these values assuming they had not previously been accounted for in the Ghanaian Task I landings. This will be further investigated by Ghanaian scientists and will be reported at the 2013 SCRS. It is less clear if the landings from the so-called "S" fleet have been incorporated into the Ghanaian Task I reports (1996-2005), since this fleet is monitored and data processed through the European system. The Group recommended this issue be further investigated and steps taken to include the data in the Ghanaian Task I if they are not presently included; conclusions will be reported at the 2013 SCRS.

[1] Sustainable Management of Tuna Fisheries and Biodiversity Conservation in the Areas Beyond National Jurisdiction (ABNJ) - A 5-year, $27 M Global Environment Facility (GEF) - funded program executed by FAO with implementing partners including WWF, NOAA, ICCAT, CCSBT, IATTC, WCPFC, IOTC, ISSF, BirdLife International, Ghana, and others, designed to promote efficient and sustainable management of fisheries resources and biodiversity conservation in the ABNJ, in accordance with the global targets agreed in international forums. - See more at: http://iwlearn.net/iw-projects/4581

3.2 *Activities conducted within the framework of the Working Plan of collaboration between Ghanaian scientists and IRD as defined by the Tropical Tunas Species Group*

Activities concerning the port samplings and introduction/validation of the data

The results of the second mission conducted in Tema in November 2012 by EU experts were presented (SCRS/2013/020). Results of the November 2012 mission revealed that differences in sampling between the ICCAT 'expert' teams and the Ghanaian samplers were no longer apparent as observed in the July 2012 mission in terms of size structure and species composition. The sampling bias detected in July 2012, which has now been addressed, reinforces the assumption that: (1) the proportion of skipjack in the catch was underestimated in recent years; and (2) recommendations provided for undertaking an accurate random sampling of landings were successfully implemented by the MRFD team. SCRS/2013/020 depicts the composition and tasks of the MFRD team in Tema as well as a brief description of some "warnings" produced in the data validation process. It appears that the majority of the "warnings" in the validation process can easily be resolved. Nevertheless, in some cases the data entry and validation process does not permit accounting for situations when the Ghanaian data from purse seiner sets are made in collaboration with a baitboat.

The document gives some advice for future treatments to improve the data entry and validation process, such as T3 software (which allows correcting logbook information with sampling data and, if necessary, performing some time-area strata substitutions). This treatment as well as the updates of data entry and validation process should be done in 2013 as part of the IRD-Ghana work plan adopted by the SCRS (ICCAT, 2013b). It was also suggested that the Ghanaian team update the AVDTH version 3.2 to a new version that includes Ghanaian-specific fishery characteristics.

Criteria to be considered in the processing of the most recent data (up to 2006)

Based on information in SCRS/2013/022, the Group discussed the ongoing development of T3-Ghana software. It was mentioned that in case of the lack of some data (e.g., in 2007), T3-Ghana will not solve this problem. Because some stock assessments will be conducted in 2014, the Group considered that the situation of the recent Ghanaian statistics should be clarified before the 2013 SCRS meeting and requested an update on when this software will be operative. The Group was informed that this point will be discussed during the annual meeting conducted between EU tuna scientists and African partners including Ghanaian scientists, in April 2013. The Group considered that the continuation of this collaboration has high priority and requested to be informed of progress realized on the issue within the framework of the IRD-MFRD collaboration plan. Considering this, the Group decided to wait for the result of the April meeting to further discuss implementation of T3 in Ghana. Progress will be communicated by mail to the ICCAT Secretariat and the Chairs of SCRS and the Tropical Tunas Species Group.

4. Responses to the Commission

4.1 FADs Management Plan

The *Recommendation by ICCAT on a Multi-Annual Conservation and Management Program for Bigeye and Yellowfin Tunas* [Rec. 11-01] requests the Secretariat to report on the content of the FAD Management Plans to SCRS for review at each annual meeting. The FAD Management Plan as currently defined comprises a mandatory component (number of FADs to be deployed per vessel; description of FAD characteristics and FAD markings), and an optional component.

In 2012, six flag States submitted FAD Management Plans and only three of these included the mandatory information, such as the number of FADs to be deployed per vessel. Besides being incomplete, the information received in these Management Plans was not considered by the SCRS to be useful for stock assessment or for improving the Committee's ability to advise the Commission.

For this reason, the Committee recommended that the Commission revisit the requirements for FAD monitoring included in the [Rec. 11-01] (paragraphs 17-19 and Annexes 1 and 2 of the Recommendation). In this respect, two primary types of information were identified to be collected and reported: An inventory of FADs and FAD activity ("FAD logbook": FAD markings, deployment, retrievals, etc.), and a record of encounters of fishing (and supply) vessels with the FADs ("Fishing logbook": visits to FADs and catches from sets made on the FADs). And these two types of information should be linked through the FAD ID or marking.

The Group regrets that no progress has been made regarding the modification of Rec. 11-01 during the 2012 Commission meeting. The Group reiterates that the Commission should revisit the requirements for FAD monitoring included in [Rec. 11-01] in the terms defined by the SCRS in 2012 that were included in the proposal by the Chairman of the Panel 1 "Draft Recommendation by ICCAT Amending the Recommendation on a Multi-Annual Conservation and Management Program for Bigeye and Yellowfin tunas".

Document SCRS/2013/029 presented the FAD Management Plan put in place by the Spanish fisheries administration in collaboration with the Spanish Institute of Oceanography which is obligatory for their freezer purse seine fleet targeting tropical tuna in the Atlantic, Indian and Pacific Oceans. **Table 4** shows the format for FAD inventory, including all information pertaining to the type, shape and material of the object and type of buoy. Each object and buoy is marked so that it can be followed throughout its lifetime. **Table 5** shows the format for gathering information on activity over FADs. This form contains an identification field for the FAD in order to connect it to the inventory form. Other fields are provided for buoy identification, information about the activity over the object (fishery, visit, loss, change of buoy, etc.), date and time, position and (in the event of a set) estimated total of tuna and bycatch.

The Group considers this experience as a very positive reference for FAD fishery monitoring and that it could be used as an example to be followed by other purse seine fleets operating in the Atlantic. The authors explained that a common ID system was defined to facilitate the monitoring and that the supply vessels are also integrated within the Plan. It was also mentioned that other countries are instituting similar systems (e.g., Ghana). The Group noted that it will be necessary that the SCRS analyze ways to deal with the advancements in the collection and archival of this type of information through the Sub-Committee of Statistics.

The Group noted that some national scientists have been working with satellite tracking of FADs (VMS/echosounder) which seen to show good promise in developing techniques for further monitoring stock status. The Group encourages further development and collaboration between scientist and fishing organizations in investigations and the use of these data and techniques.

4.2 Evaluation of the port sampling plan aimed at collecting fishery data for BET, YFT and SKJ that are caught in the geographical area of the area/time closure developed by the SCRS in 2012

Recommendation 11-01 requested the SCRS to develop, by 2012, a Port Sampling Plan aimed at collecting fishery data for bigeye, yellowfin, and skipjack tunas that are caught in the geographical area of the area/time closure.

The SCRS developed a Port Sampling Plan in 2012 in line with the existing multi-species sampling programs in Abidjan (for sampling and monitoring the European and associated fleets) and in Tema (for the component of the Ghanaian and other fleets landing in this port). According to paragraph 32 of [Rec. 11-01], beginning in 2013, the port sampling program had to be implemented in landing or transhipment ports.

In 2012 the SCRS identified some fundamental aspects that had to be solved in order to implement the sampling plan: (a) the reinforcement of the sampling teams working in Abidjan and Tema; (b) to ensure that all vessels from any flag landing in each landing port are sampled according with the established sampling scheme; and (c) to guarantee that the sampling teams can access to all vessels landing at port, independently of their flag and including cargo vessels.

The Group received information about the collaborative activities that were and are being conducted for the improvement of port sampling and data collection. It was noted that the sampling team in Tema has been reinforced in 2013 which is resulting in better monitoring of the landings during the period of the moratoria. There remain some problems in accessing logbooks of Ghanaian vessels landing in Abidjan together with some difficulties in accessing data from foreign flagged vessels landing in Tema, which should be resolved.

According to the information available to the Group, the coverage by observers onboard the EU and associated fleets and the Ghanaian fleet during the moratoria was almost complete, with the exception of one Ghanaian purse seiner.

5. Recommendations

1. The Group recommends that Ghana continue the efforts to improve the capabilities to monitor the activities of its fleet in order to guarantee the necessary coverage for the collection of the required statistical data. Such monitoring should include at-sea observations, sampling catches, as well as collection of complete and accurate fishing logbooks from all vessels.

2. In view of the importance of the catches of tropical tunas made in association with FADs, the Group reiterates the recommendation of expanding the request on FADs information of Rec. 11-01 to include the collection of detail data as proposed by the SCRS in 2012. It is also recommended that the SCRS analyze the progress on the FAD data collection in the future and discuss the ways of transmission of these data for incorporation in the ICCAT database or assessments.

3. Recognizing that the collection of data on fishing operations associated with FADs is considered as a priority by the different tuna RFMOs, it is recommended that a common format for data collection be developed based on existing experience in order to harmonize it.

4. It is also recommended that the information from VMS of tropical tuna fleets be made available to national and ICCAT scientists in the highest resolution available. The Group notes that such information is important for scientific evaluations and assessment although not necessary in real time and that a delay of one year could be sufficient for scientific utilization.

5. The Group recommends further evaluations of enhanced fleet monitoring be conducted, including the adoption of tools such as onboard electronic observation to complement the work of human observers onboard.

6. Recognizing the improvement in the Ghanaian data collection and processing the ~~WG~~ Group strongly recommends reinforcing the implementation of the IRD-MFRD collaboration plan with the full participation of the Ghanaian scientists in the process.

7. The Group recommends issuing a service contract according to the Terms of Reference specified in **Table 3**.

6. Other matters

No other matters were discussed.

7. Adoption of the report and closure

The Chairman thanked the participants of the meeting for the hard work conducted and the *Instituto Español de Oceanografía* for hosting the meeting and for the assistance provided. The report was adopted and the meeting adjourned.

References

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RÉUNION INTERSESSION 2013 DU
GROUPE D'ESPÈCES SUR LES THONIDÉS TROPICAUX

(Ténérife (Espagne), 18-21 mars 2013)

1. Ouverture, adoption de l'ordre du jour et organisation des sessions

La réunion a été tenue au Centre océanographique des Canaries de l'Institut espagnol d'océanographie (IEO), à Ténérife, du 18 au 21 mars. Le Dr Pilar Pallarés, Secrétaire exécutive adjointe de l'ICCAT, a ouvert la réunion. Le Dr Pallarés a souhaité la bienvenue aux participants et a remercié l'IEO pour accueillir la réunion dans les excellentes installations du nouveau centre aux îles Canaries et lui fournir toute la logistique requise. Le Dr Joao G. Pereira, rapporteur général du Groupe d'espèces sur les thonidés tropicaux, a présidé la réunion.

L'ordre du jour (**Appendice 1**) a été adopté avec quelques changements. La liste des participants se trouve à l'**Appendice 2.** La liste des documents présentés à la réunion est jointe à l'**Appendice 3.**

Le Dr Pereira a rappelé au Groupe d'espèces sur les thonidés tropicaux (ci-après dénommé « le Groupe ») que l'objectif de la réunion avait été défini dans le Plan de travail pour les thonidés tropicaux au titre de 2012 approuvé par le SCRS (ICCAT, 2013a).

Les personnes suivantes ont assumé les fonctions de rapporteur :

P. Pallarés	Points 1, 6 et 7
D. Die, C. Brown, J.P. Hallier, J. Million, A. Fonteneau	Point 2
G. Scott, D. Gaertner	Point 3
J. Santiago	Point 4
J. Pereira	Point 5

2. Révision et actualisation du programme AOTTP élaboré en 2010

2.1 Résumé du développement du programme AOTTP

L'effort de marquage réalisé dans l'océan Atlantique a été très faible si on le compare avec celui de l'océan Indien et de l'océan Pacifique. Des paramètres biologiques essentiels qui sont requis pour appuyer les évaluations des stocks font défaut ou sont mal connus et le récent niveau d'exploitation des trois espèces de thonidés tropicaux demeure incertain. C'est pourquoi le SCRS a proposé en 2010 la réalisation d'un programme de marquage des thonidés tropicaux de l'océan Atlantique (AOTTP). Ce nouveau programme devrait englober tout l'océan Atlantique et disposer d'un niveau de financement comparable aux programmes de marquage de thonidés menés à grande échelle dans les océans Pacifique et Indien. À la réunion de 2012 du SCRS, il a été décidé que, pour accélérer l'élaboration de cette proposition, le Groupe d'espèces sur les thonidés tropicaux examinerait les leçons apprises du programme de marquage des thonidés de l'océan Indien (IOTTP), mettrait au point des objectifs spécifiques pour l'AOTTP et identifierait, si nécessaire, les termes de référence pour un contrat en appui au développement de l'AOTTP. Au début de 2013, le Groupe d'espèces sur les thonidés tropicaux a convenu d'inviter et de financer la participation d'experts du programme de marquage des thonidés de l'océan Indien à cette réunion intersession. Ces deux experts, Julien Million et Jean Pierre Hallier, ont présenté de façon détaillée les leçons apprises de l'IOTTP et ont participé aux discussions du Groupe.

2.2 Résultats et leçons de l'IOTTP

On a informé le Groupe des principaux résultats de l'IOTTP (CTOI, 2012) mis en œuvre de 2002 à 2009 et des différents aspects qui devraient être pris en compte pour le développement d'un vaste programme de marquage de thonidés similaire dans l'océan Atlantique. Ce programme était une combinaison d'un programme à grande échelle, le programme de marquage régional de thonidés dans l'océan Indien (RTTP-IO), financé par le DG-Développement de l'Union européenne (14 millions d'euros) et de plusieurs opérations à petite échelle (Maldives, Indonésie, Mayotte, Inde, etc.) financées par la DG Affaires maritimes et pêche de l'Union européenne et du Gouvernement du Japon. La Commission des thons de l'océan Indien (CTOI) était chargée de la supervision du RTTP-IO et de la mise en œuvre des opérations à petite échelle.

Pendant l'IOTTP, plus de 200.000 thonidés tropicaux ont été marqués et remis à l'eau, principalement dans l'océan Indien occidental et jusqu'à ce jour, plus de 32.000 ou 16% ont été récupérés et déclarés. Le programme a fait apparaître que même si les coûts encourus dans les opérations menées à petite échelle dans l'océan Indien étaient plus faibles que ceux encourus dans l'opération à grande échelle (environ 35€/poisson marqué par opposition à 85€/poisson marqué), la qualité de l'information de marquage et de récupération des marques n'était pas aussi bonne et c'est pourquoi à compter d'aujourd'hui, les données obtenues des opérations à petite échelle sont d'usage limité pour appuyer les évaluations des stocks. Ceci souligne le fait que le succès des programmes de marquage devrait être mesuré non seulement par le nombre de poissons marqués ou le coût moyen par poisson marqué, mais qu'il devrait aussi tenir compte du nombre de récupérations de marques obtenues et contenant des informations utiles ainsi que du coût de leur obtention.

Les objectifs généraux et spécifiques de l'IOTTP ont été atteints et au jour d'aujourd'hui, la CTOI utilise régulièrement les données de marquage dans ses évaluations de stocks. Les analyses des données ont fait apparaître de nouveaux schémas de croissance complexes pour l'albacore et le thon obèse, très différents des courbes de croissance von Bertalanffy antérieurement utilisées, ainsi qu'un niveau plus faible de mortalité naturelle. Les déplacements rapides et de longue portée des trois espèces de thonidés tropicaux dans l'océan Indien ont été documentés. On a signalé que les thons parcouraient plus de 700 milles nautiques pendant de courtes périodes de moins d'un mois.

La liste suivante contient des leçons apprises de l'IOTTP qu'il conviendrait de prendre en compte lors de la mise en place de l'AOTTP :

- Les objectifs devraient être clairement définis.
- La structure, l'échelle et la durée du programme devraient être adaptées à ces objectifs.
- Les normes et procédures relatives au financement (p.ex. Fonds de développement européen) devraient être bien appréhendées et traitées dans la phase de la conception.
- Il convient de bien planifier le calendrier des différents contrats (p.ex. assistance technique, navire affrété, équipement, etc.).
- Dotation en personnel du programme à la fois pour la phase de marquage et de récupération des marques.
- Les accords d'accès/permis de pêche devraient être sollicités avant le début du marquage.
- Les procédures de marquage et de récupération des marques devraient être bien définies.
- La publicité et le plan de récupération devraient démarrer dès le début du marquage ou même avant.
- Les bases de données tant pour le marquage que pour la récupération devraient être développées et centralisées au Secrétariat de l'ICCAT.
- Il convient de bien définir les procédures consistant à relier les données de récupération des marques aux données des carnets de pêche, notamment les récupérations des marques provenant des senneurs.
- Il convient de mettre en œuvre les activités d'implantation de marques pendant toute la durée du programme à bord des senneurs, tout comme les autres activités afin de pouvoir estimer le taux de déclaration pour les autres pêcheries (p.ex. pêcherie palangrière).

Le Groupe a reconnu les excellents résultats de l'IOTTP et a fait remarquer que même si le marquage s'est légèrement concentré dans certaines parties de l'océan Indien occidental, les différents objectifs du programme ont été atteints. Ceci était dû en partie à la technique de pêche en bancs associés mise en œuvre au large de la côte de la Tanzanie, méthode développée dans l'océan Atlantique et désormais couramment utilisée par plusieurs pêcheries en Afrique occidentale, aux Canaries, aux Açores, etc.

Le Groupe a convenu que l'objectif général de l'AOTTP est similaire à celui du RTTP-IO. C'est pourquoi l'expérience acquise de l'IOTTP, notamment le RTTP-IO à grande échelle, serait très utile pour définir le programme et une étude de faisabilité. Le Groupe a reconnu que la charge administrative de ce programme sur le Secrétariat de l'ICCAT serait grandement accrue et qu'il aura probablement besoin d'un appui, de façon interne ou en dehors du programme. Le Groupe a également constaté que plusieurs bailleurs de fonds potentiels pourraient être contactés et qu'une gamme de financement pourrait offrir une meilleure flexibilité et garantir un usage effectif des fonds.

L'IOTTP est parvenu à des conclusions supplémentaires qui concernent particulièrement le développement de l'AOTTP, à savoir :

- Les taux de perte des marques sont aisément quantifiables à partir des études de double marquage.
- Les poissons marqués sur des navires opérant à la canne et hameçon sont récupérés par le navire de marquage. Toutefois, ces poissons peuvent être remis à l'eau vivants s'ils sont en bon état et rejoindre la portion marquée du stock. Certains de ces poissons ont été récupérés plusieurs fois.
- Le déploiement de poissons porteurs de marques reliées par satellite n'a pas été couronné de succès dans le cadre de l'IOTTP. Cependant, la technologie s'est améliorée depuis lors. Des expériences récentes menées dans le golfe du Mexique et des études antérieures réalisées dans le Pacifique sur l'albacore indiquent que les marques électroniques sont une option viable pour les thonidés tropicaux.
- Si l'on compare la réussite des composantes à grande échelle et à petite échelle de l'IOTTP, on est enclin à penser qu'il vaudrait mieux que l'AOTTP se concentre sur un sous-ensemble de flottilles de pêche pour lesquelles il est possible d'estimer les taux de déclaration des marques et/ou de garantir un taux élevé de déclaration des marques.
- L'AOTTP devrait solliciter la coopération des pays qui disposent de programmes d'observateurs embarqués sur des navires dans la zone de la Convention de l'ICCAT et s'assurer que ces observateurs obtiennent les ressources et les primes adéquates pour déclarer les poissons marqués.
- Les expériences d'implantation de marques visant à estimer les taux de transmission des marques peuvent être efficacement réalisées sur les senneurs, mais il convient de concevoir des méthodes pour les mener à bien au sein d'autres flottilles.
- Les marques associées à de fortes récompenses qui sont communément utilisées pour estimer les taux de transmission dans d'autres pêcheries pourraient rencontrer des problèmes dans les flottilles où de fortes récompenses peuvent engendrer des différends entre les armateurs, les capitaines et les membres d'équipage.
- Les données créées par ce programme de marquage devraient être diffusées une fois que l'on se sera assuré que les données confidentielles ont été supprimées et que l'équipe du programme a eu une chance raisonnable de tirer parti de ses efforts en produisant des documents scientifiques.
- La gestion des fonds fournis par l'UE est sujette à des contraintes et normes spécifiques qui donnent lieu à des frais administratifs considérables. Le coût de cette gestion devrait être pris en compte dans la conception de l'AOTTP.
- Une étude de faisabilité doit être effectuée dans le cadre du développement de l'AOTTP. Cette étude doit étudier tous les aspects du programme : administratif, juridique, financier et scientifique.
- L'ébauche initiale de la proposition de l'AOTTP devrait fournir différentes échelles optionnelles auxquelles le programme peut être mis en œuvre. L'étude de faisabilité doit évaluer ces options.
- Les frais d'affrètement des navires opérant à la canne et hameçon sont liés aux coûts opportunistes des navires disponibles qui sont fortement liés aux prix futurs des thonidés capturés à la ligne et à l'hameçon.

2.3 Examen des objectifs et des priorités pour l'AOTTP

Le Groupe a utilisé les objectifs présentés dans le rapport du SCRS de 2012 (ICCAT, 2013) comme point de départ des discussions (**Tableau 1**).

Le Groupe a ensuite décidé qu'il faudrait décrire le programme AOTTP comme ayant le but global d'améliorer la durabilité des ressources de thonidés tropicaux en fournissant à l'ICCAT la meilleure science disponible (Rés. 11-17). Ce but sera atteint par le biais des quatre objectifs suivants :

- Estimer les récents taux d'exploitation des thonidés tropicaux.
- Déterminer l'étendue de l'interaction entre les pêcheries de surface et de palangre.
- Évaluer l'efficacité des mesures de gestion (p.ex. fermetures spatio-temporelles, gestion des DCP, etc.).
- Accroître la capacité d'évaluation des thonidés tropicaux dans les pays du groupe des États d'Afrique, des Caraïbes et du Pacifique (pays ACP).

Afin d'atteindre ces objectifs, le Groupe d'espèces sur les thonidés tropicaux a défini une série d'objectifs opérationnels spécifiques pour le programme. Le Groupe a ensuite établi l'ordre de priorité de ces objectifs afin de faciliter le développement de l'AOTTP. La hiérarchisation s'est faite en classant les objectifs selon deux critères : les bénéfices potentiels apportés à l'évaluation des stocks de thonidés tropicaux et la faisabilité d'atteindre l'objectif avec l'AOTTP. La priorité générale a été établie à parts égales au plus faible des deux classements assignés. Les objectifs et les priorités correspondantes font apparaître (**Tableau 2**) que ce programme devrait avoir pour priorité maximale de confirmer les postulats actuels sur la structure des stocks des thonidés tropicaux, d'estimer la récente mortalité de pêche spécifique à la zone et spécifique à la flottille, indépendamment des données de CPUE, et d'estimer les taux de croissance des thonidés tropicaux spécifiques à l'âge et spécifiques à la zone. En outre, des objectifs importants consistent à estimer la mortalité naturelle spécifique à l'âge et à contribuer à l'évaluation des stocks de deux espèces de thonidés mineurs : la bonite à dos rayé et le thon à nageoires noires.

Le Groupe a également discuté de la meilleure stratégie pour mettre en œuvre l'AOTTP, notamment des sources éventuelles de financement en appui à celui-ci. Après les discussions, le Groupe a convenu d'une série d'actions devant être entreprises afin de garantir la poursuite du développement du programme. Il a également identifié quelques groupes et personnes clefs qui seraient chargés de réaliser ces actions, ainsi que d'éventuelles sources de financement en appui aux différents stades de l'AOTTP (**Figure 1**).

Le Groupe a décidé que des termes de référence devraient être élaborés pour un nouveau coordinateur du Groupe de travail AOTTP. Ce nouveau coordinateur devrait aider le Groupe de travail AOTTP à accomplir les premières étapes du développement de l'AOTTP (**Tableau 3**).

Le Groupe a convenu que le Groupe de travail AOTTP existant, constitué des membres du Groupe d'espèces sur les thonidés tropicaux, doit identifier et communiquer avec les principaux collaborateurs des agences qui sont susceptibles de financer les deux composantes principales du programme (à savoir DG-MARE et DG-DEVCO, États-Unis, pays membres asiatiques de l'ICCAT). L'**Appendice 4** fournit des informations détaillées sur les démarches initiales entreprises par le Groupe auprès des agences de financement potentielles. Pareillement, le Groupe de travail AOTTP doit identifier les principaux collaborateurs dans quelques-uns des pays ACP de façon à ce que ces derniers puissent faciliter la demande de lettres d'appui auprès des gouvernements de ces pays. La première tâche du Groupe de travail consistera à proposer une étude de faisabilité destinée à appuyer la conception de l'AOTTP. En fonction des résultats de l'étude de faisabilité, le Groupe de travail AOTTP élaborera une deuxième proposition destinée à la mise en œuvre de l'AOTTP. Les propositions d'étude de faisabilité et le programme de l'AOTTP devront peut-être intervenir conjointement afin de garantir le succès du financement.

2.4 Développement de la conception scientifique du programme de marquage

Un élément essentiel de l'étude de faisabilité sera le développement d'une conception scientifique détaillée et réaliste du programme, qui sera critique pour l'évaluation des exigences opérationnelles et des coûts. NOTE : Le cadre de la conception scientifique qui est présenté ici reflète les discussions du Groupe ; le Groupe de travail AOTTP peut, s'il le souhaite, élargir et affiner ce cadre. En règle générale, cette conception devrait tenir compte des objectifs et des priorités définis par le SCRS, et fournir un plan opérationnel sur la façon dont ceux-ci peuvent être atteints. Il conviendrait de fournir des estimations sur la précision des diverses estimations concernant différents niveaux d'effort de marquage, ainsi que des recommandations sur des nombres optimaux, les stratégies de déploiement (p.ex. engin, moment, zone) et le mélange des marques (marques conventionnelles, marques-archives pop-up et internes). Les stratégies de déploiement des marques et les efforts visant à optimiser les taux de récupération et de déclaration devraient être conçus de façon à refléter la gamme totale (à la fois au niveau spatial et temporel) des espèces.

L'étude devrait être conçue dans le but d'atteindre (ou d'inclure) les éléments essentiels suivants :

- Une standardisation des opérations de marquage (formation/compétence des marqueurs, navires, etc.).
- Estimations précises et exactes de la mortalité en rapport avec le marquage, la perte des marques et les taux de déclaration spécifiques aux flottilles.
- Sensibilisation du public afin d'optimiser la déclaration des marques récupérées, avec des informations complètes, et le retour des marques-archives récupérées.
- Plans de contingence visant à garantir la couverture des zones de pêche non accessibles ou inadaptées pour les opérations de marquage standard.

Comme il a été indiqué auparavant, le Groupe de travail AOTTP pourrait identifier d'autres éléments essentiels.

Cette conception devrait tenir compte de la logistique nécessaire à la réalisation des stratégies recommandées. À titre d'exemple, même si les canneurs pourraient s'avérer être la meilleure plateforme pour les déploiements de marques réalisés à grande échelle, les opérations des canneurs dépendent de la disponibilité des appâts. Pour certaines régions, il pourrait être nécessaire d'envisager des alternatives (p.ex. navires récréatifs, navires commerciaux adéquats). Pareillement, les conditions océanographiques ou le comportement des poissons pourraient avoir un impact sur l'accessibilité ou la capturabilité dans certaines zones ; il conviendrait de tenir compte de ces considérations.

Pour de nombreuses zones, les pêcheries prédominantes pourraient s'avérer être celles qui connaissent habituellement de faibles taux de déclaration (p.ex. palangriers). C'est pourquoi la sensibilisation du public et la publicité, notamment en établissant en permanence des contacts directs avec les capitaines des navires, constituent un élément extrêmement important.

De surcroît, les marques-archives pop-up reliées par satellite (PSAT) peuvent jouer un rôle important, surtout compte tenu du faible taux de déclaration de nombreuses pêcheries. La récupération et la déclaration des marques par un navire de pêche ne visent pas nécessairement l'obtention de ces données ; ces marques transmettent des données récapitulées (y compris des estimations sur la profondeur de la nage, la température de l'eau et le lieu) après s'être détachées des poissons. Ceci peut fournir des informations critiques sur la mortalité par marquage, les taux de migration et les schémas de mélange des stocks. Les marques-archives internes peuvent également recueillir ces données, évitant d'éventuelles difficultés liées à leur fixation, mais elles dépendent des pêcheries pour leur récupération et leur retour. Les données des marques-archives (pop-up ou internes) peuvent aussi fournir les données nécessaires à l'identification des profils préférés d'habitat ainsi que d'importants comportements, qui sont extrêmement importants pour l'interprétation et la standardisation des indices d'abondance et des tendances de la pêcherie et pourraient s'avérer critiques pour les futures évaluations basées sur l'écosystème.

Un important principe sous-jacent pour cette étude est que les données recueillies par le biais d'activités financées par ce programme seront mises à la disposition des scientifiques de l'ICCAT. Il s'agit notamment des données des marques-archives électroniques au niveau de résolution le plus détaillé.

Pour illustrer le rôle que peut jouer la modélisation par simulation dans la conception de l'étude, un modèle général de marquage capture-récupération a été mis au point avant la réunion et a été présenté au Groupe (SCRS/2013/031). Ce cadre statistique, qui peut servir à estimer le mélange des stocks ainsi que les taux de mortalité naturelle et de mortalité par pêche, pourrait être appliqué à une vaste gamme d'espèces migratoires atlantiques et être adapté en vue de répondre à divers objectifs de l'étude. Le Groupe a fait remarquer que les résultats de la simulation du modèle paraissaient optimistes compte tenu des tailles des échantillons simulés par rapport aux résultats du programme de la CTOI. Il a été noté qu'une raison de la variance plus faible de l'estimation prédite par rapport aux résultats observés de la CTOI était que la simulation s'appliquait à une cohorte individuelle et que la migration spécifique à l'âge et les taux de mortalité naturelle spécifiques à la région auraient besoin d'un effort de marquage bien plus grand en raison de l'erreur de détermination de l'âge.

Lors de discussions supplémentaires, il a été souligné que l'approche du modèle était différente des résultats de la CTOI en ce que les taux de migration obtenus des marques électroniques étaient incorporés comme des priors informatifs afin d'éviter l'estimation de ces taux avec les taux de mortalité. Le Groupe a également constaté que le modèle devrait intégrer la perte de marques de type 2 (observée comme étant environ de 5% par an à la CTOI), ce qui augmenterait également le coefficient de variation prédit des estimations du modèle. Le modèle fait preuve de flexibilité en ce sens qu'il est adaptable afin d'incorporer une complexité accrue (p.ex. classes d'âge, flottilles multiples, nombre de zones) et peut utiliser les informations issues des résultats d'autres études, comme le programme de marquage de la CTOI ou les études de marques-archives électroniques, afin d'affiner plus avant les postulats et les paramètres d'entrée. Le Groupe a considéré que ce modèle pouvait s'avérer être un outil utile pour évaluer les différentes hypothèses et l'effet escompté sur les estimations des paramètres en fonction de différents niveaux et stratégies de marquage.

Afin d'illustrer l'utilité potentielle des marques-archives électroniques dans le cadre du programme global, on a présenté une actualisation d'un programme des États-Unis de déploiement de PSAT sur des albacores dans le golfe du Mexique. Depuis le mois d'août 2010, ce programme a déployé 55 PSAT sur des albacores mesurant de 100 cm à 160 cm FL ; environ 80% des poissons marqués avaient des longueurs estimées entre 130 cm et 150 cm FL. Cinq (5) poissons ont été capturés à la canne et au moulinet et ont été hissés sur de petits navires pour être marqués. Le reste a été capturé à la palangre et presque tous ont été marqués dans l'eau. Onze (11) marques sont remontées à la surface moins de 10 jours après avoir été apposées, dans une grande mesure en raison des difficultés rencontrées dans la mise au point de techniques de marquage à partir d'un palangrier, trois n'ont effectué aucune transmission et quatre sont programmées pour une transmission ultérieure. Les 37 autres marques ont suivi les déplacements des poissons, enregistrant la profondeur, la température et les niveaux de luminosité (pour estimer ensuite l'emplacement) toutes les dix secondes pour des durées allant jusqu'à 172 jours, avec une durée moyenne de déploiement de 74 jours (16 marques ont été récupérées). Seuls trois poissons ont quitté le golfe du Mexique, deux au mois de juin et un en décembre. Il est intéressant de noter que les deux marques enregistrant la plus longue durée (155 et 172 jours) font apparaître des déplacements limités à une zone relativement restreinte (< 300 km) le long du bord du plateau continental et la pente adjacente proche de l'embouchure du Mississippi. On s'attend à ce que 30 à 35 marques additionnelles soient apposées à des albacores dans le golfe du Mexique, ce qui inclut les déploiements programmés dans le cadre de la collaboration entre le Mexique et les États-Unis où des PSAT seront déployées dans les eaux mexicaines dans le Sud-Ouest du golfe du Mexique.

Le Groupe a estimé que ces résultats préliminaires étaient intéressants, compte tenu des vastes déplacements qui ont été observés en utilisant les marques conventionnelles (**Figures 2-4**). Il a été noté que même si les données des marques conventionnelles confirment les déplacements d'albacores de l'Atlantique Nord-Ouest et du golfe du Mexique vers les eaux proches de l'Afrique, de nombreuses questions demeurent sur la fréquence de ces déplacements, la proportion du stock concerné et les circonstances dans lesquelles ces déplacements ont lieu. Les résultats préliminaires de cette étude sur les PSAT étayent le concept selon lequel les schémas de déplacement de l'albacore sont complexes. Ceci n'est guère surprenant, mais la description des déplacements et des migrations et la quantification des taux font grandement défaut pour les espèces de thonidés tropicaux. L'emploi de PSAT pourrait fournir d'importantes informations ; le Groupe a estimé que le déploiement de marques électroniques à travers des strates spatio-temporelles pourrait permettre de calculer des taux spatio-temporels spécifiques, même en tenant compte des durées de déploiement qui ont été atteintes jusqu'à ce jour. Si un tel déploiement spatial était possible, il servirait aussi à estimer les taux de déplacement dans les régions. C'est souvent le manque de connaissances sur ces taux de migration qui rend difficile l'estimation de la mortalité naturelle à partir des données de marquage. C'est pourquoi les études sur les PSAT pourraient être un élément clef de l'estimation de la mortalité naturelle.

3. Révision et évaluation des données de prise, d'effort et de taille de la Tâche II pour la période intermédiaire envisagée par le Groupe

Le Groupe a brièvement passé en revue les recommandations qu'il avait antérieurement formulées afin d'orienter les travaux de révision et d'évaluation des statistiques du Groupe de travail du Ghana (TFG), qui avaient été réalisés pour la première en 2011. Parmi celles-ci, on peut citer les recommandations visant à améliorer l'infrastructure et les procédures de collecte des données en vue de répondre totalement aux obligations en matière de déclaration des données, les recommandations portant sur des mécanismes permettant de répondre aux obligations en matière de données, ainsi que les recommandations techniques pour aborder ces questions (ICCAT, 2012). Même si le Groupe a fait remarquer que le TFG et l'administration ghanéenne s'occupaient tous deux d'un certain nombre de ces recommandations, il semblait exister une préoccupation élevée en ce qui concerne le caractère adéquat du suivi et du contrôle de la flottille ghanéenne, limitant éventuellement l'accès au marché des thons capturés par le Ghana. Même si le Groupe a constaté qu'il s'agissait principalement d'une question d'application, il a été suggéré qu'un nouveau renforcement du suivi de la flottille, en adoptant des outils tels que l'observation électronique de la flottille, pourrait s'avérer suffisant pour valider la performance des flottilles et répondre aux obligations en matière de déclaration des données conformément à la Convention. On a également fait remarquer que ce programme était envisagé dans le cadre du programme FAO/GEF ABNJ[2], qui sera prochainement lancé, et le Groupe a encouragé la collaboration de l'administration ghanéenne à ce programme. Le Groupe a en outre constaté que l'augmentation du personnel affecté à l'échantillonnage au sein de la *Marine Fisheries Research Division* (MFRD) permettait désormais d'améliorer la collecte des données, mais qu'il survenait encore des problèmes logistiques liés à la collecte de données, qui empêchaient l'utilisation optimale du temps du personnel et limitaient l'accès aux navires dans les ports. On a noté qu'un appui logistique accru était encore nécessaire pour pouvoir profiter pleinement du personnel d'échantillonnage disponible au port.

[2] Gestion durable des pêcheries de thonidés et conservation de la biodiversité dans les zones situées au-delà des limites de la juridiction nationale (« ABNJ ») - Fonds pour l'environnement mondial (GEF) - programme sur cinq ans, d'un coût de $27 M, exécuté par la FAO et bénéficiant de partenaires pour sa mise en œuvre, dont WWF, NOAA, ICCAT, CCSBT, IATTC, WCPFC, IOTC, ISSF, BirdLife International, Ghana, et autres, conçu pour promouvoir la gestion efficace et soutenable des ressources halieutiques et la conservation de la biodiversité dans l'ABNJ, conformément aux objectifs globaux convenus dans les enceintes internationales. Plus d'informations sur : http://iwlearn.net/iw-projects/4581.

3.1 Examen de l'état actuel des travaux réalisés par le Groupe de travail sur l'amélioration des statistiques ghanéennes

Le SCRS/2013/023 présentait l'évolution des travaux entrepris par le Groupe de travail du Ghana (TFG) en ce qui concerne l'amélioration des statistiques ghanéennes. Le document décrivait les données, les méthodes et les hypothèses proposées pour affiner les estimations de la Tâche II (statistiques de prise et effort et de prise par taille) pour la flottille ghanéenne au cours de la période 1996-2005. Ces travaux ont été réalisés sous l'égide du Plan de travail de 2013 du Groupe d'espèces sur les thonidés tropicaux et tel que proposé dans le SCRS/2012/041.

Le Groupe a examiné les travaux réalisés par le TFG, qu'il a considérés comme étant de grande qualité. Après son examen, le Groupe a suggéré qu'il serait préférable d'utiliser au maximum les informations disponibles des pêcheries ghanéennes plutôt que de trop dépendre des données de la flottille européenne comme substitut pour réviser les statistiques ghanéennes de la Tâche II de 1996-2005. Cette approche a ensuite été incorporée dans les travaux du TFG (dénommée "Hypothèse 3"), que le Groupe a adoptés. L'**Appendice 5** contient des informations détaillées sur la méthode suivie pour estimer les statistiques de la Tâche II.

Des estimations de "faux poissons" débarqués par la flottille ghanéenne ont également été produites pour la période 1996-2005 dans le SCRS/2013/023 sur la base des échantillons prélevés à Abidjan pendant cette période. Le Groupe a recommandé l'adoption de ces valeurs, postulant qu'elles n'avaient pas été prises en compte auparavant dans les débarquements ghanéens de la Tâche I. Cette question sera traitée plus avant par les scientifiques ghanéens qui en feront rapport au SCRS en 2013. Il ressort moins clairement si les débarquements de la flottille dénommée "S" ont été incorporés dans les rapports ghanéens de la Tâche I (1996-2005), étant donné que cette flottille fait l'objet d'un suivi et que les données sont traitées par le système européen. Le Groupe a recommandé que cette question soit approfondie et que des démarches soient prises en vue d'inclure les données dans la Tâche I ghanéenne si elles ne sont pas actuellement incluses ; les conclusions seront présentées au SCRS en 2013.

3.2 Activités menées dans le cadre du plan de collaboration entre les scientifiques ghanéens et l'IRD, tel que défini par le Groupe d'espèces sur les thonidés tropicaux

Activités concernant l'échantillonnage au port et introduction/validation des données

Les résultats de la deuxième mission réalisée à Tema en novembre 2012 par des experts de l'UE ont été présentés (SCRS/2013/020). Les résultats de la mission de novembre 2012 ont révélé que les différences observées entre les équipes d'experts de l'ICCAT et les échantillonneurs ghanéens n'étaient plus apparentes, comme cela avait été observé pendant la mission de juillet 2012 en termes de structure des tailles et de composition par espèces. Le biais d'échantillonnage détecté en juillet 2012, qui a désormais été résolu, renforce le postulat selon lequel : (1) la proportion du listao dans la capture a été sous-estimé au cours de ces dernières années ; et (2) l'équipe du MRFD a mis à exécution avec succès les recommandations formulées à l'effet de réaliser un échantillonnage aléatoire précis des débarquements. Le SCRS/2013/020 fournit la composition et les tâches de l'équipe du MFRD à Tema ainsi qu'une brève description de quelques "problèmes" survenus dans le processus de validation des données. Il semblerait que la majorité des "problèmes" rencontrés dans le processus de validation puissent être facilement solutionnés. Néanmoins, dans certains cas, le processus de saisie et de validation des données ne permet pas de tenir compte de situations où les données ghanéennes proviennent d'opérations à la senne qui sont réalisées en collaboration avec un canneur.

Le document donne quelques conseils pour les traitements futurs destinés à améliorer le processus de saisie et de validation des données, tels que le logiciel T3 (qui permet de corriger les informations des carnets de pêche avec les données d'échantillonnage et, si nécessaire, de procéder à quelques substitutions spatio-temporelles). Ce traitement, ainsi que les actualisations du processus de saisie et de validation des données, devraient être menés à bien en 2013 dans le cadre du plan de travail IRD-Ghana adopté par le SCRS (ICCAT, 2013b). Il a également été suggéré que l'équipe ghanéenne actualise la version 3.2 AVDTH avec une nouvelle version qui inclue des caractéristiques de la pêcherie spécifique au Ghana.

Critères à envisager lors du traitement des données les plus récentes (jusqu'en 2006)

En se basant sur l'information contenue dans le SCRS/2013/022, le Groupe a discuté du développement en cours du logiciel T3-Ghana. Il a été mentionné que si certaines données faisaient défaut (p.ex. en 2007), T3-Ghana ne résoudrait pas ce problème. Étant donné que certaines évaluations de stocks auront lieu en 2014, le Groupe a estimé que la situation des récentes statistiques ghanéennes devrait être clarifiée avant la réunion de 2013 du SCRS et il a demandé qu'on lui indique quand ce logiciel serait opérationnel. Le Groupe a été informé que ce point serait discuté à la réunion annuelle qui réunira les scientifiques thoniers de l'UE et leurs partenaires africains, dont des scientifiques ghanéens, au mois d'avril 2013. Le Groupe a considéré que la poursuite de cette collaboration était une grande priorité et a demandé à être tenu informé des progrès réalisés sur cette question dans le cadre du plan de collaboration IRD-MFRD. Compte tenu de ce qui précède, le Groupe a décidé d'attendre les résultats de la réunion d'avril afin de discuter de manière plus approfondie de la mise en œuvre de T3 au Ghana. Les progrès seront communiqués par courrier au Secrétariat de l'ICCAT et aux Présidents du SCRS et du Groupe d'espèces sur les thonidés tropicaux.

4. Réponses à la Commission

4.1 Plan de gestion des DCP

La *Recommandation de l'ICCAT sur un programme pluriannuel de conservation et de gestion pour le thon obèse et l'albacore* [Rec. 11-01] prévoit que le Secrétariat doit déclarer le contenu des plans de gestion des DCP au SCRS aux fins de leur examen à chaque réunion annuelle. Le plan de gestion des DCP, tel qu'il est actuellement défini, comprend un élément obligatoire (nombre de DCP à déployer par navire ; description des caractéristiques des DCP et marquages des DCP), et un élément facultatif.

En 2012, six États de pavillon ont présenté des plans de gestion des DCP et seuls trois d'entre eux ont inclus les informations obligatoires, telles que le nombre de DCP allant être déployés par navire. Outre leur caractère incomplet, les informations reçues dans ces plans de gestion n'ont pas été considérées utiles par le SCRS pour l'évaluation des stocks ou pour permettre au Comité d'améliorer l'avis qu'il soumet à la Commission.

C'est pourquoi le Comité a recommandé que la Commission revoie les exigences en matière de suivi des DCP établies dans la [Rec. 11-01] (paragraphes 17 - 19 et Annexes 1 et 2 de la Recommandation). À cet égard, on a identifié deux types principaux d'information qui doivent être recueillis et déclarés : inventaire des DCP et des activités sous DCP (« journal de bord consacré aux DCP » : marquages, déploiements et récupérations des DCP, etc.) et registre des visites rendues aux DCP par les navires de pêche (et les navires de ravitaillement) ("carnet de pêche" : visites rendues aux DCP et captures provenant des opérations réalisées sous DCP). Ces deux types d'informations devraient être associés à travers l'identification du DCP ou de son marquage.

Le Groupe regrette l'absence de progrès en ce qui concerne la modification de la Rec.11-01 pendant la réunion de 2012 de la Commission. Le Groupe réitère que la Commission devrait revoir les exigences en matière de suivi des DCP établies dans la [Rec. 11-01] dans les termes définis par le SCRS en 2012 qui étaient inclus dans la proposition du Président de la Sous-commission 1 "Projet de recommandation de l'ICCAT amendant la Recommandation sur un programme pluriannuel de conservation et de gestion pour le thon obèse et l'albacore".

Le document SCRS/2013/029 présentait le plan de gestion des DCP mis en place par l'administration des pêches espagnole en collaboration avec l'Institut espagnol d'océanographie qui est obligatoire pour sa flottille de senneurs congélateurs ciblant les thonidés tropicaux dans les océans Atlantique, Indien et Pacifique. Le **Tableau 4** présente le formulaire pour l'inventaire des DCP, y compris toutes les informations concernant le type, la forme et le matériel de l'objet ainsi que le type de balise. Chaque objet et chaque balise est marqué de façon à faire l'objet d'un suivi tout au long de sa durée de vie. Le **Tableau 5** présente le formulaire pour la collecte des informations sur les activités avec DCP. Ce formulaire contient un champ d'identification pour le DCP afin de le relier au formulaire d'inventaire. D'autres champs sont prévus pour l'identification de la balise, l'information sur l'activité réalisée autour de l'objet (pêche, visite, perte, remplacement de la balise, etc.), date et heure, position et (en cas d'opération de pêche) total estimé de thons capturés et de prises accessoires.

Le Groupe considère qu'il s'agit d'une expérience très positive pour le suivi de la pêche avec DCP, qui pourrait servir d'exemple à suivre pour d'autres flottilles de senneurs qui opèrent dans l'Atlantique. Les auteurs ont expliqué qu'un système commun d'identification a été défini afin de faciliter le suivi et que les navires de ravitaillement ont également été intégrés au plan. Il a également été fait remarquer que d'autres pays sont en train d'instituer des systèmes similaires (p.ex. le Ghana). Le Groupe a fait remarquer que le SCRS devra analyser les façons d'aborder les progrès dans la collecte et l'archivage de ce type d'information par le biais du Sous-comité des statistiques.

Le Groupe a fait remarquer que certains scientifiques nationaux ont travaillé avec le suivi des DCP par satellite (VMS/échosondeur) qui semble prometteur pour développer des techniques visant à un suivi plus poussé de l'état des stocks. Le Groupe encourage de poursuivre le développement et de renforcer la collaboration entre les scientifiques et les organisations de pêche au niveau de la recherche et de l'emploi de ces données et techniques.

4.2 Évaluation du programme d'échantillonnage au port visant à recueillir des données des pêcheries concernant le thon obèse, l'albacore et le listao qui sont capturés dans la zone géographique de la fermeture spatio-temporelle mise au point par le SCRS en 2012

La Rec. 11-01 prévoyait que le SCRS devait élaborer, avant 2012, un programme d'échantillonnage au port destiné à recueillir des données halieutiques sur le thon obèse, l'albacore et le listao qui sont capturés dans la zone géographique de la fermeture spatio-temporelle.

En 2012, le SCRS a élaboré un programme d'échantillonnage au port conforme aux programmes d'échantillonnage plurispécifique existants à Abidjan (pour l'échantillonnage et le suivi des flottilles européennes et associées) et à Tema (pour la composante de la flottille ghanéenne et d'autres flottilles qui débarquent dans ce port). En vertu du paragraphe 32 de la Rec. 11-01, à partir de 2013, le programme d'échantillonnage au port devait être mis en œuvre dans les ports de débarquement ou de transbordement.

En 2012, le SCRS a identifié quelques aspects fondamentaux qui devaient être résolus afin de mettre en œuvre le programme d'échantillonnage : (a) renforcer les équipes en charge de l'échantillonnage d'Abidjan et de Tema ; (b) garantir que tous les navires de tout pavillon confondu débarquant dans chaque port de débarquement soient échantillonnés conformément au programme d'échantillonnage établi ; et (c) s'assurer que les équipes d'échantillonnage aient accès à tous les navires procédant à des débarquements au port, navires de charge y compris, indépendamment de leur pavillon.

Le Groupe a reçu des informations sur les activités de collaboration réalisées et en cours de réalisation aux fins de l'amélioration de l'échantillonnage au port et de la collecte des données. Il a été fait remarquer que l'équipe d'échantillonnage à Tema a été renforcée en 2013, ce qui a donné lieu à un meilleur suivi des débarquements pendant la période du moratoire. Des problèmes persistent pour accéder aux carnets de pêche des navires ghanéens débarquant à Abidjan et il est encore difficile d'accéder aux données des navires sous pavillon étranger qui débarquent à Tema, et ces questions devront être résolues.

Selon l'information dont dispose le Groupe, la couverture des observateurs embarqués à bord des flottilles de l'UE et des flottilles associées et à bord de la flottille ghanéenne pendant le moratoire était presque complète, à l'exception d'un senneur ghanéen.

5. Recommandations

1. Le Groupe recommande que le Ghana continue à déployer les efforts nécessaires en vue de renforcer sa capacité à réaliser un suivi des activités de sa flottille de façon à garantir la couverture nécessaire à la collecte des données statistiques requises. Ce suivi devrait inclure des observations en mer, l'échantillonnage des captures, ainsi que la collecte, auprès de tous les navires, de livres de bord contenant des données complètes et exactes.

2. Compte tenu de l'importance des prises de thonidés tropicaux réalisées en association avec des DCP, le Groupe réitère la recommandation à l'effet d'élargir la demande d'information sur les DCP de la Rec.11-01 afin d'y inclure la collecte de données détaillées, tel que le proposait le SCRS en 2012. Il est également recommandé que le SCRS analyse les progrès réalisés dans la collecte des données sur les DCP à l'avenir et discute des moyens de transmission de ces données aux fins de leur incorporation dans la base de données ou les évaluations de l'ICCAT.

3. Reconnaissant que les différentes ORGP thonières considèrent comme prioritaire la collecte des données relatives aux opérations de pêche associées aux DCP, il est recommandé que soit développé un format commun de collecte de données reposant sur l'expérience existante afin de l'harmoniser.

4. Il est également recommandé que l'information sur les flottilles de thonidés tropicaux obtenue par VMS soit mise à la disposition des scientifiques nationaux et des scientifiques de l'ICCAT dans la plus haute résolution disponible. Le Groupe note que cette information est importante pour les évaluations scientifiques, même s'il n'est pas nécessaire d'en disposer en temps réel, et qu'un délai d'un an pourrait être suffisant à des fins d'utilisation scientifique.

5. Le Groupe recommande que le renforcement du suivi des flottilles fasse l'objet d'une nouvelle évaluation et que des outils soient notamment adoptés, tels que l'observation électronique à bord visant à compléter le travail des observateurs humains embarqués à bord.

6. Reconnaissant l'amélioration de la collecte et du traitement des données ghanéennes, le Groupe recommande fortement de renforcer la mise en œuvre du plan de collaboration IRD-MFRD avec la pleine participation des scientifiques ghanéens au processus.

7. Le Groupe recommande que soit élaboré un contrat de prestations de services conforme aux Termes de référence énoncés au **Tableau 3**.

6. Autres questions

Aucune autre question n'a été discutée.

7. Adoption du rapport et clôture

Le Président a remercié les participants de la réunion pour le travail qu'ils avaient réalisé ainsi que l'Institut espagnol d'océanographie pour accueillir la réunion et pour l'aide fourni. Le rapport a été adopté et la réunion a été levée.

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REUNIÓN INTERSESIONES DEL
GRUPO DE ESPECIES TROPICALES DE 2013

(Tenerife, España - 18 a 21 de marzo de 2013)

1 Apertura de la reunión, adopción del orden del día y disposiciones para la reunión

La reunión se celebró en el Centro Oceanográfico de Canarias, del Instituto Español de Oceanografía, en Tenerife, del 18 al 21 de marzo. La Dra. Pilar Pallarés, Secretaria Ejecutiva Adjunta de ICCAT, inauguró la reunión. La Dra. Pallarés dio la bienvenida a los participantes y dio las gracias al Instituto Español de Oceanografía por acoger la reunión y facilitar al Grupo todas las disposiciones logísticas del nuevo y excelente centro de las islas Canarias. El Dr. Joao Pereira, Relator general de especies tropicales, presidió la reunión.

El orden del día (**Apéndice 1**) fue adoptado con algunos cambios. La lista de participantes se adjunta como **Apéndice 2**. La lista de documentos presentados a la reunión se adjunta como **Apéndice 3**.

El Dr. Pereira recordó al Grupo de especies tropicales (en lo sucesivo, el Grupo) que el objetivo de la reunión se había definido en el plan de trabajo de 2012 para los túnidos tropicales, aprobado por el SCRS (ICCAT, 2013a).

Los siguientes participantes actuaron como relatores:

P. Pallarés	Puntos 1, 6 y 7
D. Die, C. Brown, J.P. Hallier, J. Million, A. Fonteneau	Punto 2
G. Scott, D. Gaertner	Punto 3
J. Santiago	Punto 4
J. Pereira	Punto 5

2 Revisión y actualización del AOTTP preparado en 2010

2.1 Resumen del desarrollo del Programa AOTTP

En comparación con el Pacífico, y ahora con el Índico, el esfuerzo de marcado realizado en el océano Atlántico ha sido muy escaso. Faltan, o son escasamente conocidos, algunos parámetros biológicos clave requeridos para respaldar las evaluaciones de stock y el nivel de explotación reciente de las tres especies de túnidos tropicales sigue siendo incierto. Por lo tanto, en 2010 el SCRS realizó una propuesta para un Programa de marcado de túnidos tropicales del océano Atlántico (AOTTP). Está previsto que este nuevo programa cubra todo el océano Atlántico y tenga un nivel de financiación comparable a los de los proyectos de marcado de túnidos a gran escala del océano Pacífico e Índico. En la reunión de 2012 del SCRS se decidió que, para acelerar el desarrollo de esta propuesta, el Grupo de especies de túnidos tropicales examinaría información del Programa de marcado de túnidos del océano Índico (IOTTP), desarrollaría objetivos específicos para el AOTTP e identificaría, si es necesario, términos de referencia para un contrato en apoyo del desarrollo del AOTTP. A principios de 2013, el Grupo de especies de túnidos tropicales acordó invitar y financiar la participación en esta reunión intersesiones de expertos del Programa de marcado de túnidos del océano Índico. Estos dos expertos, Julien Million y Jean Pierre Hallier, presentaron de forma detallada la experiencia aprendida en el Programa de marcado de túnidos del océano Índico y participaron en las discusiones del Grupo.

2.2. Resultados y lecciones del IOTTP

El Grupo fue informado de los principales resultados alcanzados en el IOTTP (IOTC, 2012), implementado desde 2002 a 2009, así como de diferentes aspectos a tener en cuenta para el desarrollo de un programa similar de marcado de túnidos a gran escala en el Atlántico. Este Programa era una combinación de un proyecto a gran escala, el Proyecto regional de marcado de túnidos en el océano Índico (RTTP-IO), financiado por la Dirección General de desarrollo de la Unión Europea (14 millones de euros) y varias operaciones a pequeña escala (Maldivas, Indonesia, Mayotte, India, etc.), financiadas por la Dirección General de Pesca y Asuntos Marítimos de la Unión Europea y el Gobierno de Japón. La Comisión del Atún para el océano Índico (IOTC) estaba a cargo de la supervisión del RTTP-IO y de la implementación de las operaciones a pequeña escala.

Durante el IOTTP, se marcaron y liberaron más de 200.000 túnidos tropicales, principalmente en el océano

Índico occidental y, hasta ahora, más de 32.000, o el 16%, han sido recuperados y declarados. El programa demostró que aunque los costes de las operaciones a pequeña escala en el océano Índico eran inferiores a los de las operaciones a gran escala (aproximadamente 35 €/pez marcado frente a 85 €/pez marcado), la calidad de la información de marcado y recaptura no era tan buena, y por tanto, a día de hoy los datos obtenidos en las operaciones a pequeña escala tienen un uso limitado en apoyo de las evaluaciones de stock. Esto hace destacar el hecho de que el éxito de los programas de marcado debería medirse no solamente por el número de ejemplares marcados o el coste medio por pez marcado, sino que también debería considerarse el número de recapturas obtenidas con información útil y el coste de obtenerlas.

Los objetivos generales y específicos del IOTTP se lograron y, actualmente, los datos de marcado se utilizan de forma rutinaria en las evaluaciones de stock de la IOTC. El análisis de los datos ha demostrado nuevos y complejos patrones de crecimiento para el rabil y el patudo, muy diferentes de las curvas de crecimiento de von Bertalanffy previamente utilizadas y un nivel menor de mortalidad natural. Se han documentado movimientos rápidos y de largo alcance de las tres especies de túnidos tropicales en el océano Índico. Se ha comunicado que los túnidos viajan más de 700 mn en cortos periodos de tiempo, menos de 1 mes.

A continuación se presenta una lista de lecciones aprendidas del IOTTP que deberían tenerse en cuenta al diseñar el AOTTP:

- Los objetivos deben estar claramente definidos.
- La estructura, escala y duración del programa deberían adaptarse a estos objetivos.
- Las normas y procedimientos vinculados a la financiación (por ejemplo, el Fondo europeo de desarrollo) deberían entenderse bien y abordarse en la fase de diseño.
- El calendario de los diferentes contratos (es decir, asistencia técnica, buque fletado, equipamiento, etc.) debería estar bien planeado.
- Dotación de personal para el programa, tanto para la fase de marcado como para la de recuperación.
- Los acuerdos de acceso/permisos de pesca deberían solicitarse antes del inicio del marcado.
- Los procedimientos de marcado y recuperación deberían estar bien definidos.
- La publicidad y el plan de recuperación deberían iniciarse a la vez que el marcado, o incluso antes.
- Deberían desarrollarse y centralizarse en la Secretaría de ICCAT bases de datos tanto para el marcado como para la recuperación.
- Deberían definirse bien los procedimientos para vincular los datos de recuperaciones con los datos de los cuadernos de pesca, en especial para las recuperaciones procedentes del cerco.
- En los buques de la pesquería de cerco las actividades de detección de marcas deberían implementarse durante toda la duración del proyecto, así como otras actividades para poder estimar la tasa de comunicación de otras pesquerías (es decir, palangre).

El Grupo reconoció los excelentes resultados del IOTTP e indicó que aunque las colocaciones podrían haber estado ligeramente concentradas en algunas partes del océano Índico occidental, se habían logrado los diferentes objetivos del proyecto. Esto se debió en parte a la técnica de pesca sobre bancos asociados implementada en aguas de la costa de Tanzania, un método utilizado en el océano Atlántico y que ahora se utiliza de forma rutinaria en varias pesquerías de África occidental, Canarias, Azores, etc.

El Grupo acordó que el objetivo general del AOTTP es similar al del RTTP-IO. Por tanto, la experiencia del IOTTP y en particular del RTTP-IO, a gran escala, será muy útil para definir el proyecto y llevar a cabo un estudio de viabilidad. El Grupo reconoció que la carga administrativa para la Secretaría de ICCAT se verá enormemente aumentada con este proyecto, y que esta probablemente requerirá algún apoyo, a través del proyecto o desde fuera de él. El Grupo también indicó que podría contactarse con varios posibles donantes y que una variedad de financiación podría ofrecer una mejor flexibilidad y garantizar una utilización eficaz de los fondos.

A continuación se presentan conclusiones adicionales alcanzadas por el IOTTP pertinentes para el desarrollo del AOTTP:

- Las tasas de desprendimiento de marcas son fácilmente cuantificables a partir de estudios de doble marcado.
- Los peces marcados en los buques de caña y liña son recapturados por el buque de marcado, sin embargo, dichos peces pueden liberarse vivos si están en buenas condiciones y volver a unirse a la parte marcada del stock. Algunos de estos peces fueron recapturados muchas veces.
- La colocación de marcas satélite no tuvo mucho éxito en el IOTTP, sin embargo, la tecnología ha mejorado desde entonces. Experiencias recientes en el golfo de México y estudios anteriores sobre el rabil en el Pacífico indican que las marcas electrónicas son una opción viable para los túnidos tropicales.
- La comparación del éxito de los componentes de pequeña y gran escala del IOTTP sugiere que podría ser mejor centrar el AOTTP en un subconjunto de flotas pesqueras para las que es posible, o bien estimar las tasas de comunicación de marcas, o bien garantizar una elevada tasa de comunicación de marcas.
- El AOTTP debería buscar la colaboración de los países que cuentan con programas de observadores a bordo de buques en la zona del Convenio ICCAT e invertir en garantizar que estos observadores tienen los incentivos y recursos adecuados para comunicar los peces marcados.
- Los experimentos de detección para estimar las tasas de comunicación de las marcas pueden llevarse a cabo de forma eficaz en los cerqueros, pero deben desarrollarse los métodos para llevarlos a cabo en otras flotas.
- Las marcas de elevada recompensa, comúnmente utilizadas para estimar las tasas de comunicación en otras pesquerías, podrían plantear problemas en las flotas en las que las elevadas recompensas pueden crear disputas entre los armadores, los patrones y la tripulación.
- Los datos procedentes de dicho proyecto de marcado deberían hacerse públicos tras haber eliminado adecuadamente los datos confidenciales y después de que el equipo del programa haya tenido una oportunidad razonable de aprovechar sus esfuerzos en la producción de documentos científicos.
- La gestión de los fondos proporcionados por la UE está sujeta a normas y limitaciones específicas que pueden crear unos importantes gastos generales administrativos. En el diseño del AOTTP debería considerarse el coste de dicha gestión.
- Como parte del desarrollo del AOTTP, debe llevarse a cabo un estudio de viabilidad. Este estudio deberá investigar todos los aspectos del programa: administrativos, legales, financieros y científicos.
- El borrador inicial de la propuesta del AOTTP debería proporcionar diferentes escalas opcionales en las que podría implementarse el programa. El estudio de viabilidad deberá evaluar estas opciones.
- Los costes de fletar los buques de caña y liña están vinculados a los costes de oportunidad de los buques disponibles, que están estrechamente relacionados con el precio futuro del atún capturado con caña y liña.

2.3 Examen de los objetivos y prioridades del AOTTP

El Grupo de especies tropicales utilizó los objetivos presentados en el informe del SCRS de 2012 (ICCAT, 2013) como punto de partida de las discusiones (**Tabla 1**).

El Grupo decidió posteriormente que el programa AOTTP debería describirse como un programa que tiene un objetivo global de mejorar la sostenibilidad de los recursos de túnidos tropicales proporcionando a ICCAT la mejor ciencia disponible [Res. 11-17]. Este objetivo se logrará mediante los siguientes cuatro objetivos:

- Estimar las recientes tasas de explotación de los túnidos tropicales;
- Determinar el alcance de la interacción entre las pesquerías de superficie y las de palangre;
- Evaluar la eficacia de las medidas de ordenación (por ejemplo vedas espacio-temporales, ordenación de los DCP, etc.) y
- Aumentar la capacidad de evaluar los túnidos tropicales en los países de África, del Caribe y del Pacífico (países ACP).

Con el fin de lograr estos objetivos, el Grupo de especies de túnidos tropicales definió una serie de objetivos operativos específicos para el programa. Posteriormente el Grupo estableció prioridades entre dichos objetivos con miras a facilitar el desarrollo del AOTTP. Se logró establecer prioridades graduando los objetivos según dos criterios: los posibles beneficios que se aportarán a las evaluaciones de los stocks de túnidos tropicales y la viabilidad de lograr el objetivo con el AOTTP. La prioridad global se estableció en un nivel igual a la inferior de las dos clasificaciones asignadas. Los objetivos y las prioridades correspondientes asignadas muestran que (**Tabla 2**) las mayores prioridades del programa deberían ser confirmar los supuestos actuales acerca de la estructura de stock de los túnidos tropicales, estimar la reciente mortalidad por pesca específica del área y específica de la flota independientemente de los datos de CPUE y estimar las tasas de crecimiento de los túnidos tropicales específicas de la edad y específicas del área. Además, otros objetivos importantes son estimar la mortalidad natural específica de la edad y contribuir a la evaluación de stock de dos especies de pequeños túnidos, el bonito Atlántico y el atún aleta negra del Atlántico.

El Grupo de especies de túnidos tropicales discutió también la mejor estrategia para implementar el AOTTP, lo que incluye las posibles fuentes de financiación para respaldarlo. Tras una discusión, el Grupo acordó una serie de acciones que deben llevarse a cabo para garantizar el desarrollo continuado del programa. Asimismo, identificó algunos individuos y grupos clave que serían los responsables de llevar a cabo estas acciones y algunas posibles fuentes de financiación para apoyar las diferentes etapas del AOTTP (**Figura 1**).

El Grupo acordó desarrollar los términos de referencia para un nuevo coordinador del grupo de trabajo del AOTTP. Este nuevo coordinador ayudará al grupo de trabajo del AOTTP a dar los primeros pasos en el desarrollo del AOTTP (**Tabla 3**).

El Grupo acordó que el grupo de trabajo existente del AOTTP, formado por miembros del Grupo de especies de túnidos tropicales, debe identificar a colaboradores clave en agencias que sean posibles candidatas a financiar los dos principales componentes del programa y comunicarse con ellos (por ejemplo, DG-MARE y DG-DEVCO, Estados Unidos, países asiáticos miembros de ICCAT). Los detalles de los enfoques iniciales realizados por el Grupo de trabajo sobre posibles agencias de financiación se facilitan en el **Apéndice 4**. De forma similar, el Grupo de trabajo del AOTTP debe identificar colaboradores clave en algunos países ACP para que dichos colaboradores puedan facilitar la solicitud de cartas de apoyo de los gobiernos de estos países. El primer resultado del Grupo de trabajo será una propuesta para un estudio de viabilidad con el fin de respaldar el diseño del AOTTP. Teniendo en cuenta los resultados del estudio de viabilidad, el Grupo de trabajo de la AOTTP desarrollará una segunda propuesta, esta vez para la implementación del AOTTP. Las propuestas para el estudio de viabilidad y el programa AOTTP podrían tener que realizarse juntas para garantizar el éxito de la financiación.

2.4 Desarrollo del diseño científico del Programa de marcado

Un componente esencial del estudio de viabilidad será el desarrollo de un diseño científico del programa realista y detallado, que será esencial para la evaluación de los costes y los requisitos operativos. NOTA: El marco de este diseño científico presentado aquí refleja las discusiones del Grupo, el grupo de trabajo del AOTTP podría ampliar y perfilar este marco de trabajo. En general, este diseño debería abordar los objetivos y prioridades definidos por el SCRS, proporcionando un plan operativo sobre cómo pueden lograrse. Deben realizarse estimaciones sobre la precisión de las diversas estimaciones para niveles diferentes de esfuerzo de marcado, así como recomendaciones sobre números óptimos, estrategias de colocación (por ejemplo, arte, momento, área) y una mezcla de marcas (es decir, convencionales, archivo, pop-up e internas). Las estrategias de colocación de marcas y los esfuerzos para optimizar las tasas de recaptura y comunicación deberían diseñarse de tal forma que reflejen el rango total (tanto espacial como temporal) de las especies.

El estudio debería diseñarse para lograr (o incluir) los siguientes elementos esenciales:

- Una estandarización de las operaciones de marcado (formación/capacitación de los marcadores, buques, etc.)
- Estimaciones precisas y exactas de la mortalidad relacionada con el marcado, desprendimiento de marcas, tasas de comunicación específicas de cada flota.
- Divulgación pública para optimizar la comunicación de las marcas recuperadas, con información completa, y la devolución de las marcas archivo recuperadas.
- Planes de contingencia para garantizar una cobertura de los caladeros no accesibles o no adecuados para las operaciones estándar de marcado.

Como se ha indicado anteriormente, el Grupo de trabajo del AOTTP puede identificar elementos esenciales adicionales.

Este diseño debería tener en cuenta la logística implicada al llevar a cabo las estrategias recomendadas. Por ejemplo, aunque los cañeros son, generalmente, la mejor plataforma para las colocaciones de marcas a gran escala, las operaciones de cebo vivo están limitadas por la disponibilidad de cebo. Para algunas regiones, podría ser necesario considerar alternativas (por ejemplo, buques de recreo, buques comerciales adecuados). Igualmente, las condiciones oceanográficas o el comportamiento de los peces podrían tener su impacto en la accesibilidad o capturabilidad en ciertas zonas, y dichas consideraciones deberían tenerse en cuenta.

Para muchas zonas, las pesquerías predominantes podrían ser las que normalmente presentan bajas tasas de comunicación (por ejemplo, el palangre). Por tanto, la publicidad y divulgación públicas, lo que incluye el contacto directo continuo con los capitanes de los buques, es un elemento extremadamente importante.

Además, las marcas archivo pop-up por satélite (PSAT) pueden desempeñar un importante papel, especialmente teniendo en cuenta las bajas tasas de comunicación previstas en muchas pesquerías. Para obtener estos datos no es necesaria la recuperación y comunicación por parte de un buque pesquero, estas marcas transmiten datos resumidos (que incluyen las estimaciones de profundidad de natación, temperatura del agua y localización) después de desprenderse del pez. Esto puede proporcionar información crítica sobre la mortalidad por marcado, las tasas de migración y los patrones de mezcla del stock. Las marcas archivo internas también pueden recoger estos datos, evitando las posibles dificultades debidas al desprendimiento, pero dependen de que las pesquerías las recuperen y las devuelvan. Los datos de las marcas archivo (pop-up o internas) también pueden proporcionar los datos necesarios para identificar perfiles de hábitat preferidos, así como comportamientos importantes, que son extremadamente útiles para la interpretación y estandarización de los índices de abundancia y de las tendencias pesqueras, y que pueden ser esenciales para futuras evaluaciones basadas en el ecosistema.

Un importante principio de este estudio es que los datos recopilados a través de las actividades financiadas mediante este programa se pondrán a disposición de los científicos de ICCAT. Esto incluye los datos de las marcas archivo electrónicas con el nivel de resolución más detallado.

Como ejemplo del papel que los modelos de simulación pueden desempeñar en el diseño del estudio, antes de la reunión se desarrolló un modelo de marcado general captura-recaptura que fue presentado al grupo (SCRS/2013/031). Este marco estadístico, que puede usarse para estimar la mezcla del stock, las tasas de mortalidad natural y de mortalidad por pesca, podría aplicarse a una amplia gama de especies migratorias del Atlántico y adaptarse para cumplir varios de los objetivos del estudio. El Grupo comentó que los resultados del modelo de simulación parecían optimistas teniendo en cuenta los tamaños de la muestra simulada en comparación con los resultados del programa de la IOTC. Se indicó que una razón para la inferior estimación de la varianza predicha en comparación con los resultados observados de la IOTC era que la simulación se aplicó a una cohorte individual y que la migración específica de la edad y las tasas de mortalidad específicas de la región requerirían un esfuerzo de marcado mucho más grande debido al error de determinación de la edad.

En discusiones adicionales se indicó que el enfoque del modelo era diferente de los resultados de la IOTC en que las tasas de migración de las marcas electrónicas están incorporadas como distribuciones previas informativas para evitar la estimación de estas tasas con las tasas de mortalidad. El Grupo también señaló que el modelo debería integrar la pérdida de marcas tipo 2 (que en la IOTC se ha observado en aproximadamente el 5% anualmente), lo que aumentaría también el coeficiente predicho de variación de las estimaciones del modelo. El modelo es flexible en cuanto a que se puede adaptar para incorporar mayor complejidad (por ejemplo, clases de edad, varias flotas, número de áreas) y puede utilizar información sobre los resultados de otros estudios, como el programa de marcado de la IOTC o estudios de marcas archivo electrónicas, con el fin de mejorar los supuestos y los parámetros de entrada. El Grupo consideró que este modelo podría ser una herramienta útil para evaluar diferentes hipótesis y el efecto previsto sobre las estimaciones de parámetros en el marco de diferentes estrategias y niveles de marcado.

Para ilustrar la utilidad potencial del marcado con marcas archivo electrónicas como parte del programa general, se presentó una actualización del programa estadounidense de colocación de PSAT en rabiles en el Golfo de México. Desde agosto de 2010, en el marco de este programa se colocaron 55 PSAT en rabiles de 100 a 160 cm FL, aproximadamente el 80% de los peces marcados tenían una FL estimada de entre 130 y 150 cm. Cinco (5) ejemplares se capturaron con artes de caña y carrete y se izaron a bordo de pequeños barcos para el marcado. El resto se capturó con palangre, y casi todos ellos se marcaron en el agua. Once (11) marcas emergieron tras menos de 10 días, debido en gran medida a las dificultades que surgieron al desarrollar las técnicas de marcado desde un palangrero, tres no transmitieron información y cuatro estaban programadas para transmitir información posteriormente. Las 37 marcas restantes rastrearon los movimientos de los peces, registrando la profundidad, temperatura y niveles de luz (para una estimación posterior de la localización) cada diez segundos durante hasta 172 días, con una duración media de los despliegues de 74 días (se recuperaron 16 marcas). Sólo tres ejemplares salieron del Golfo de México, dos en junio y uno en diciembre. Cabe señalar que las dos marcas con mayor duración (155 y 172 días) mostraban movimientos restringidos a una zona relativamente pequeña (< 300 km), a lo largo del extremo de la plataforma continental y del talud adyacente cerca de la desembocadura del Mississippi. Se prevé la colocación de 30-35 marcas adicionales en rabiles en el Golfo de México, lo que incluye el marcado realizado encuadrado en la colaboración entre México y Estados Unidos para colocar PSAT en aguas mexicanas en la parte suroccidental el Golfo de México.

El Grupo consideró que los resultados preliminares eran interesantes, dados los movimientos a gran escala que se han observado con marcas convencionales (**Figuras 2-4**). Se constató que, aunque los datos de marcado convencional confirman que el rabil se desplaza desde el Atlántico noroccidental y el Golfo de México hasta aguas cercanas a África, siguen existiendo preguntas sobre la frecuencia de estos movimientos, la proporción de stock implicada y las circunstancias en las cuales se realizan dichos movimientos. Los resultados preliminares de este estudio PSAT respaldan el concepto de complejidad de los patrones de movimiento del rabil. Esto no es sorprendente, pero hay una importante carencia en lo que concierne a la caracterización de los movimientos y migraciones, así como a la cuantificación de las tasas para los túnidos tropicales. La utilización de PSAT podría proporcionar información importante; el Grupo consideró que la colocación de marcas electrónicas en diferentes estratos espaciales y temporales permitiría calcular tasas espacio temporales específicas, incluso considerando las duraciones de los despliegues que se han conseguido hasta la fecha. Si dicho despliegue en diferentes zonas fuera posible, también contribuiría a la estimación de tasas de movimientos entre diferentes regiones. A menudo esta falta de conocimiento de las tasas de migración dificulta la estimación de la mortalidad natural a partir de los datos de marcado. Por tanto, los estudios PSAT podrían ser una clave para estimar también la mortalidad natural.

3 Revisión y evaluación de los datos de Tarea II de captura/esfuerzo y talla para el periodo intermedio considerado por el Grupo

El Grupo de túnidos tropicales (TTWG) examinó brevemente las recomendaciones que había formulado anteriormente para orientar el trabajo de revisión y evaluación de las estadísticas realizado por primera vez en 2011 por el Grupo de trabajo de Ghana (TFG). Entre ellas había recomendaciones sobre mejoras en la infraestructura y procedimientos de recopilación de datos para abordar plenamente las obligaciones de comunicación de datos, recomendaciones para establecer mecanismos para el cumplimiento de las obligaciones respecto a datos, así como recomendaciones técnicas para abordar estas cuestiones (véase el Informe del SCRS de 2012). Aunque el TTWG constató que muchas de estas recomendaciones estaban siendo abordadas por el TFG y la administración de Ghana, actualmente parece haberse generado una preocupación mayor para adecuar el control y seguimiento de la flota ghanesa, lo que posiblemente tendría como resultado una reducción en el acceso al mercado para el atún capturado por Ghana. Aunque el Grupo indicó que esto era básicamente una cuestión de cumplimiento, se sugirió que una mejora del seguimiento de la flota mediante la adopción de herramientas como la observación electrónica de la flota podría proporcionar medios suficientes para validar el funcionamiento de la flota y cumplir las obligaciones de comunicación de datos en el marco del Convenio. También se indicó que dicho programa se había previsto en el marco del programa FAO/GEF ABNJ[3], que pronto se pondrá en marcha, y el TTWG instó a la administración de Ghana a que colabore con el proyecto. Además, el TTWG indicó que el incremento del personal de muestreo en puerto por parte del MFRD permite ahora mejorar la recopilación de datos, pero siguen surgiendo problemas logísticos en lo que concierne al respaldo para la recopilación de datos, lo que impide la utilización óptima del tiempo del personal y limita el acceso a los buques que se hallan en el puerto. Se indicó que se requiere un incremento del apoyo logístico para poder sacar el mayor provecho del personal de muestreo en puerto disponible.

[3] La ordenación sostenible de las pesquerías de túnidos y la conservación de la biodiversidad en zonas más allá de la jurisdicción nacional (ABNJ), un programa de cinco años del Fondo Global para el Medio Ambiente (GEF) con una financiación de 27 millones de dólares, ejecutado por FAO, con socios implementadores como WWF, NOAA, ICCAT, CCSBT, IATTC, WCPFC, IOTC, ISSF, BirdLife International, Ghana, y otros, se concibió para fomentar la ordenación eficaz y sostenible de los recursos pesqueros y la conservación de la biodiversidad en las ABNJ, de conformidad con los objetivos globales acordados en foros internacionales. Más información en: http://iwlearn.net/iw-projects/4581

3.1 Examen del estado actual del trabajo realizado por el Grupo de trabajo para mejorar las estadísticas de Ghana

En el documento SCRS/2013/023 se presentaban los progresos del trabajo emprendido por el Grupo de trabajo de Ghana (TFG) en relación con la mejora de las estadísticas de Ghana. En el documento se describían datos, métodos e hipótesis propuestos para mejorar las estimaciones de Tarea II (estadísticas de captura y esfuerzo y de captura por talla) para la flota ghanesa durante el periodo 1996-2005. Este trabajo se realizó siguiendo las orientaciones generales del Plan de trabajo para 2013 del Grupo de especies sobre túnidos tropicales y tal y como se propuso en el documento SCRS/2012/041.

El Grupo revisó el trabajo realizado por el TFG, y concluyó que el trabajo era de gran calidad. Al revisar el trabajo, el Grupo sugirió que utilizar al máximo la información disponible de las pesquerías de Ghana era un enfoque preferible a depender en gran medida de los datos de la flota europea como sustituto a la hora de revisar las estadísticas de Ghana de Tarea II para 1996-2005. Este enfoque se incorporó posteriormente al trabajo del TFG (y se denominó hipótesis 3) y fue adoptado por el Grupo. En el **Apéndice 5** se incluye información detallada sobre el método utilizado para estimar las estadísticas de Tarea II.

En el documento SCRS/2013/023 también se generaron las estimaciones de "faux poisson" desembarcado por la flota ghanesa durante el periodo 1996-2005, basándose en las muestras recopiladas en Abiyán durante dicho periodo. El TTWG recomendó la adopción de estos valores asumiendo que antes no se habían incluido en los desembarques de Ghana de Tarea II. Esta cuestión será examinada de nuevo por los científicos de Ghana que informarán de ello al SCRS en 2013. Queda menos claro si los desembarques de la denominada flota "S" han sido incorporados en los informes de Tarea I de Ghana (1996-2005), ya que el seguimiento de esta flota y el procesamiento de los datos se realiza a través del sistema europeo. El Grupo recomendó que se siga investigando esta cuestión y que se emprendan acciones para incluir los datos en la Tarea I de Ghana si no se habían incluido hasta la fecha. Las conclusiones se comunicarán a la reunión del SCRS de 2013.

3.2 Revisión de las actividades llevadas a cabo en el marco del plan de colaboración entre científicos de Ghana y el IRD definido por el Grupo de especies tropicales

Actividades de muestreo en puerto e introducción/validación de datos

Se presentaron los resultados de la segunda misión realizada en Tema, en noviembre de 2012, por expertos de la UE (SCRS/2013/020). Los resultados de la misión de noviembre de 2012 revelaron que ya no se observaban las diferencias en el muestreo entre los equipos de expertos de ICCAT y los muestreadores de Ghana que se habían detectado en la misión de julio de 2012 en términos de estructura de tallas y composición de especies. El sesgo en el muestreo detectado en julio de 2012, que ya se ha solucionado, respalda el supuesto de que (1) la proporción de listado en la captura había sido subestimada en años recientes y (2) el equipo del MRFD ha implementado adecuadamente las recomendaciones que establecían que se emprenda un muestreo aleatorio preciso de los desembarques. El documento SCRS/2013/020 refleja la composición y tareas del equipo de MFRD en Tema, así como una breve descripción de algunos "problemas" en el proceso de validación de datos. Parece que la mayoría de los "problemas" en lo que concierne al proceso de validación pueden resolverse fácilmente. Sin embargo, en algunos casos el proceso de introducción y validación de datos no permite tener en cuenta las situaciones en las que los datos ghaneses recopilados proceden de lances de cerco realizados en colaboración con cebo vivo.

El documento proporciona orientación sobre la aplicación de tratamientos en el futuro para mejorar el proceso de introducción y validación de datos, como el programa informático T3 (que permite corregir la información de los cuadernos de pesca con datos de muestreo y, si es necesario, realizar algunas sustituciones de estratos espacio-temporales). Este tratamiento, así como las actuaciones de los procesos de introducción y validación de datos deben realizarse en 2013, como parte del plan de trabajo IRD-Ghana adoptado por el SCRS (ICCAT, 2013b). Se sugirió también que el equipo ghanés actualice la versión 3.2 AVDTH con una nueva versión que incluya las características específicas de la pesquería de Ghana.

Criterios para considerar en el tratamiento de los datos más recientes (hasta 2006)

Basándose en la información recogida en el documento SCRS/2013/022, el TTWG debatió el desarrollo actual del programa Ghana-T3. Se mencionó que en el caso de que falten algunos datos (por ejemplo, en 2007), Ghana-T3 no resolverá este problema. Dado que en 2014 se realizarán algunas evaluaciones de stock, el Grupo consideró que la situación de las estadísticas recientes de Ghana debería aclarase antes de la próxima reunión del

SCRS, y solicitó una actualización sobre cuándo estará operativo el programa informático. Se informó al Grupo de que este punto se debatiría durante la reunión anual entre los científicos expertos en atunes de la UE y sus socios africanos, lo que incluye los científicos ghaneses, cuya celebración estaba prevista para abril de 2013. El Grupo consideró que era muy necesario que continúe esta colaboración, y solicitó que se le informe de los progresos alcanzados en esta cuestión en el marco del plan de colaboración IRD-MFRD. Considerando lo anterior, el TTWG decidió esperar a los resultados de la reunión de abril para seguir debatiendo la implementación del T3 en Ghana. Se indicó que se comunicarían los progresos por correo electrónico a la Secretaría de ICCAT y a los Presidentes del TTWG y del SCRS.

4 Respuestas a la Comisión

4.1 Plan de ordenación de los DCP

En la Rec. 11-01 se solicita a la Secretaría que informe de los contenidos de los planes de ordenación de los DCP al SCRS, para su revisión en cada reunión anual. El plan de ordenación de los DCP, tal y como se ha definido actualmente, incluye un componente obligatorio (número de DCP que se va a plantar por buque, descripción de las características de los DCP y marcas de los DCP) y un componente opcional.

En 2012, seis Estados de pabellón presentaron sus planes de ordenación de los DCP, y sólo tres de ellos incluyeron la información obligatoria, como el número de DCP que se iba a plantar por buque. Además de estar incompleta, el SCRS consideró que la información recibida en estos planes de ordenación no era útil a efectos de evaluación de stock o a la hora de mejorar la capacidad del Comité de ofrecer asesoramiento a la Comisión.

Por ello, el Comité recomendó que la Comisión volviera a examinar los requisitos de seguimiento de los DCP incluidos en la Rec. 11-01 (párrafos 17-19 y Anexos 1 y 2 de la Recomendación). En este sentido, se identificaron dos tipos principales de información que tenían que recopilarse y comunicarse: Un inventario de DCP y de las actividades de los DCP ("cuadernos de pesca- DCP": marcas en los DCP, DCP plantados, recuperaciones, etc.) y un registro de visitas de los buques de pesca (y auxiliares) a los DCP ("cuadernos de pesca": visitas a DCP y capturas de lances realizados en DCP). Estos dos tipos de información deberían vincularse mediante las marcas o identificadores de los DCP.

El Grupo manifestó su pesar por el hecho de que no se hayan realizado progresos en la modificación de la Rec. 11-01 durante la reunión de la Comisión de 2012. El Grupo reiteró la recomendación de que la Comisión vuelva a examinar los requisitos de seguimiento de los DCP incluidos en la Rec. 11-01 siguiendo los términos definidos por el SCRS en 2012, que se incluyeron en la propuesta del Presidente a la Subcomisión 1 "Proyecto de Recomendación de ICCAT para enmendar la Recomendación sobre un programa plurianual de conservación y ordenación para el patudo y el rabil".

En el documento SCRS/2013/029 se presentaba el plan de ordenación de los DCP establecido por la administración pesquera española en colaboración con el Instituto Español de Oceanografía, que es obligatorio para la flota de cerqueros congeladores que se dirige a los túnidos tropicales en los océanos Atlántico, Índico y Pacífico. En la **Tabla 4** se muestra el formulario para el inventario de DCP, que incluye toda la información sobre el tipo, forma y material del dispositivo, así como sobre el tipo de baliza. Todos los dispositivos y balizas tienen que marcarse para poder rastrearlos durante toda su vida útil. En la **Tabla 5** se muestra el formulario para recopilar la información sobre la actividad en los DCP. Este formulario incluye un campo de identificación para los DCP para poder vincularlo con el formulario de inventario. También se incluyen otros campos para la identificación de las balizas, información sobre la actividad en el dispositivo (pesca, visita, pérdida, cambio de baliza, etc.) fecha y hora, posición y (en el caso de lance) total estimado de túnidos y de captura fortuita.

El Grupo considera que esta experiencia supone una referencia muy positiva para el seguimiento de las pesquerías con DCP y que podría utilizarse a modo de ejemplo por otras flotas de cerco que operan en el Atlántico. Los autores explicaron que se había definido un sistema de identificación común para facilitar el seguimiento y que los buques de apoyo también se habían integrado en el plan. Se mencionó también que otros países están estableciendo sistemas similares (por ejemplo, Ghana). El Grupo indicó que será necesario que el SCRS analice modos de abordar los avances en la recopilación y archivo de este tipo de información a través del Subcomité de estadísticas.

El Grupo indicó que algunos científicos nacionales habían estado trabajando con sistemas de rastreo de DCP vía satélite (VMS/ecosonda) que parecen muy prometedores en cuanto al desarrollo de técnicas para un mejor seguimiento del estado del stock. El Grupo insta a que se continué el desarrollo y la colaboración entre científicos y organizaciones pesqueras en lo que concierne a las investigaciones y la utilización de estos datos y técnicas

4.2 Evaluación del plan de muestreo en puerto con el objetivo de recopilar datos pesqueros para el patudo, rabil y listado capturados en la zona geográfica de la veda espaciotemporal desarrollada por el SCRS en 2012

La Rec. 11-01 solicitaba al SCRS que desarrollase antes de 2012 un plan de muestreo en puerto con el objetivo de recopilar datos pesqueros para el patudo, rabil y listado capturados en la zona geográfica de la veda espaciotemporal.

En 2012, el SCRS desarrolló un plan de muestreo en puerto acorde con los programas de muestreo multiespecíficos existentes en Abiyán (para realizar un seguimiento y muestreo de las flotas europea y asociada) y en Tema (para el componente de la flota ghanesa y para otras flotas que desembarcan en dicho puerto). De conformidad con el párrafo 32 de la Rec. 11-01, a partir de 2013, el muestreo en puerto debe implementarse en los puertos de desembarque o de transbordo.

En 2012 el SCRS identificó algunos aspectos fundamentales que tienen que resolverse con el fin de implementar el plan de muestreo: a) reforzar los equipos de muestreo que trabajan en Abiyán y Tema; b) garantizar que todos los buques de cualquier pabellón que desembarcan en cada puerto de desembarque sean muestreados de conformidad con el programa de muestreo establecido, y c) garantizar que los equipos de muestreo puedan acceder a todos los buques que desembarcan en el puerto, independientemente de su pabellón e incluidos los buques de transporte.

El Grupo recibió información sobre actividades de colaboración que se habían realizado y que se estaban realizando con miras a la mejora del muestreo en puerto y de la recopilación de datos. Se indicó que este año se había reforzado el equipo de muestreo en Tema, lo que dio lugar a un mejor seguimiento de los desembarques durante el periodo de la moratoria. Quedan por resolver algunos problemas relacionados con el acceso a los cuadernos de pesca de los buques ghaneses en Abiyán, junto con algunas dificultadas a la hora de acceder a datos de buques con pabellón extranjero que desembarcan en Tema. Estas cuestiones deberían resolverse.

De conformidad con la información disponible para el Grupo, la cobertura de observadores a bordo de los buques de la flota UE y asociada y de la flota ghanesa durante la moratoria fue prácticamente total, con la excepción de un cerquero de Ghana.

5 Recomendaciones

1. El Grupo de trabajo recomienda que las autoridades de Ghana continúen con los esfuerzos encaminados a mejorar las capacidades de seguimiento de las actividades de sus flotas para garantizar la cobertura necesaria para la recopilación de los datos estadísticos requeridos. Dicho seguimiento debería incluir observaciones en el mar, lo que incluye el muestreo de captura, así como la recopilación de los cuadernos de pesca de los buques que contengan con datos precisos y completos.

2. Ante la importancia de las capturas de túnidos tropicales realizadas en asociación con DCP, el Grupo reitera la recomendación de ampliar la solicitud de información sobre DCP de la Rec. 11-01 para incluir la recopilación de datos detallados tal y como propuso el SCRS en 2012. También se recomendó que el SCRS analice en el futuro los progresos realizados en la recopilación de datos sobre DCP y debata los modos de transmitir estos datos e incorporarlos en la base de datos de ICCAT o en las evaluaciones.

3. Reconociendo que la recopilación de datos sobre operaciones de pesca asociadas con DCP es considerada una prioridad por diferentes OROP de túnidos, se recomienda que se desarrolle un formato común para la recopilación de datos, basándose en la experiencia existente para armonizarlo.

4. También se recomienda que la información VMS de las flotas de túnidos tropicales se ponga a disposición de los científicos nacionales y de ICCAT con el mayor nivel de resolución disponible. El Grupo indicó que dicha información es importante para las evaluaciones científicas, aunque no es necesario que dicha información sea en tiempo real, y recibir la información un año después sería suficiente para su utilización científica.

5. El Grupo recomienda que se realicen más evaluaciones del seguimiento mejorado de la flota, lo que incluye herramientas como la observación electrónica a bordo para complementar el trabajo realizado por observadores humanos a bordo.

6. Reconociendo la mejora en la recopilación y procesamiento de datos de Ghana, el Grupo recomienda encarecidamente el reforzamiento de la implementación del plan de colaboración IRD-MFRD, con la plena participación de los científicos ghaneses en el proceso.

7. El Grupo recomienda que se establezca un contrato de prestación de servicios que siga los términos de referencia especificados en la **Tabla 3**.

6 Otros asuntos

No se discutieron otros asuntos.

7 Adopción del informe y clausura

El Presidente expresó su agradecimiento a los participantes en la reunión por el duro trabajo realizado y al Instituto Español de Oceanografía por haber acogido la reunión y por la asistencia facilitada. El informe fue adoptado y la reunión clausurada.

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TABLEAUX

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Table 1. Objectives of AOTTP as presented in 2010 (ICCAT, 2011a).

- The extent of movements of the three main tropical tunas species (yellowfin, skipjack and bigeye) throughout the entire Atlantic Ocean and its potential effect on the revision of the present stock structure hypothesis;
- The recent levels of exploitation across the entire range of the stocks and to reduce uncertainties in parameter estimates (with special attention to integrated stock assessment models that can potentially incorporate capture-recaptures data);
- The improvement of age- and area-specific population parameters (e.g., natural mortality by age/size, movement rates, sex- and area- specific growth etc) as well as their geographical and inter-annual variability (for instance by comparison with results obtained during historical tagging programs.)
- The level of interaction between surface and longline fisheries throughout the Atlantic Ocean; specifically for bigeye and yellowfin tuna (assuming an improvement of the recovery rate of tags on longliners);
- The interactions between the 3 major tuna species in terms of a multispecies approach of stock assessment, their habitat uses and their respective integration in habitat based model;
- The effect of the use of FADs by purse seiner in the Gulf of Guinea on the movement patterns and biology of skipjack (at all ages) and of juveniles bigeye and yellowfin, as in the associated school fishing technique in some bait boat fisheries (the “ecological trap” hypothesis), as well as the residence time of tunas around seamounts and other features;
- Characterizing and quantifying the effects of environmental factors on the movements and behaviors of each species, which may be size-dependent;
- The analysis of survival rates for released fish in case of size-catch regulation.

Table 2. List of operational objectives for AOTTP, ratings of importance for stock assessment and feasibility of reaching objective with tagging program and overall priority of each objective.

Operational objective	*Description*	*Ratings*		*Priority*
		Stock status	*Feasibility*	
Movements and stock structure	Confirm current stock structure for tropical tunas by studying their movements.	High	High	High
Fishing mortality	Estimate recent fishing mortality rates in a way that is not dependent on catch and CPUE.	High	High	High
Growth	Estimate age-area-sex specific growth rates.	High	High	High
Natural mortality	Estimate age-specific natural mortality rates.	High	Medium	High/Medium
Assessment of small tunas	Contribute to the assessment of Atlantic blackfin tuna and Atlantic bonito.	High	Medium	Medium
Environmental factors	Study the link between environmental conditions and distribution and abundance of tropical tunas.	Medium	Medium	Medium
Habitat and behavior	Describe the habitat used by tropical tunas to help in the interpretation of relative abundance indices derived from CPUE.	Medium	Low	Low
Interactions between tropical tunas	Determine whether fishery productivity of tropical tunas is independent of the productivity of each stock.	Low	High	Low
Survival rates for released fish	Estimate the survival of tropical tuna after release from fishing operations.	Low	High	Low
FADs	Determine whether the use of FADs changes the ecology and population dynamics of tropical tunas.	Medium	Low	Low
Spawning	Improve knowledge on spawning patterns for tropical tunas.	Low	Low	Low

Table 3. Draft Terms of Reference for Coordinator of AOTTP Task Force.

Requirements:

- At least 3 years of experience managing and implementing a large tagging program for marine fish in developing countries.
- Knowledge of tropical tuna fisheries.

Duties:

- Coordinate the AOTTP task force in the development of a proposal for a feasibility study to support the design of the AOTTP.
- Work with collaborators at potential donor agencies and ACP countries to seek support for the funding of the feasibility study.
- Coordinate and development of revised draft of the AOTTP proposal.
- Work with collaborators at EU and ACP countries to seek support for the funding of the AOTTP proposal.

Deliverables

- Present a revised draft of the AOTTP proposal to the 2013 SCRS annual meeting on the status of development.
- Report on type of interactions with potential donor agencies and ACP countries to the 2013 SCRS annual meeting.
- Proposal for feasibility study delivered to the SCRS 2013 annual meeting.

Duration of contract:	6 months, effort 3 months
Start of the contract:	May 1, 2013
Possible funding sources:	AOTTP funding program seed funds

Table 4. Format for FAD inventory (introduced in 2013).

ANEX I: Inventory

Vessel ____________ **Registration** ______

FAD					FAD Dimensions			Rabo/Tail					Identification associated buoy	Type of associated buoy	Withdrawal or loss of FAD
Identification	Description	Material			width (m)	length (m)	height (cm)	depth (m)	material			mesh (mm)			

Table 5. Format for collecting information on activity over FADs (introduced in 2013).

ACTIVITY REGISTER

Vessel: ______________________________ Registration: ________

Date	*Time*	*FAD identification*	*Buoy identification*	*Activity*	*Position*		*Estimation of school (ton)*	*Estimation of accidental bycatch*				*Observations*
					Lat	*Long*		*Group*	*In no. specimens or weight (t)*	*No./W*	*No. specimens released alive*	
D/M/Y	**H/Min**				**Degree/Min**	**Degree/Min**						

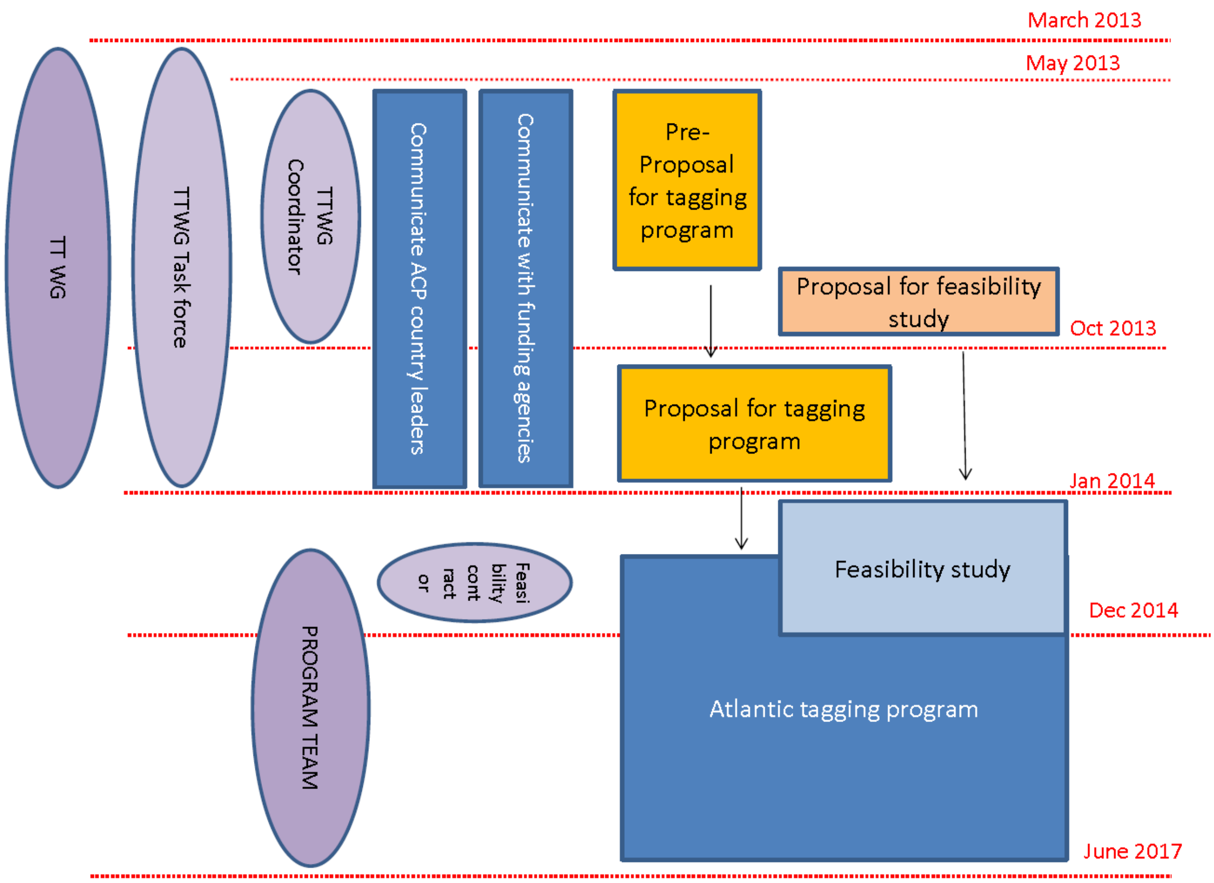
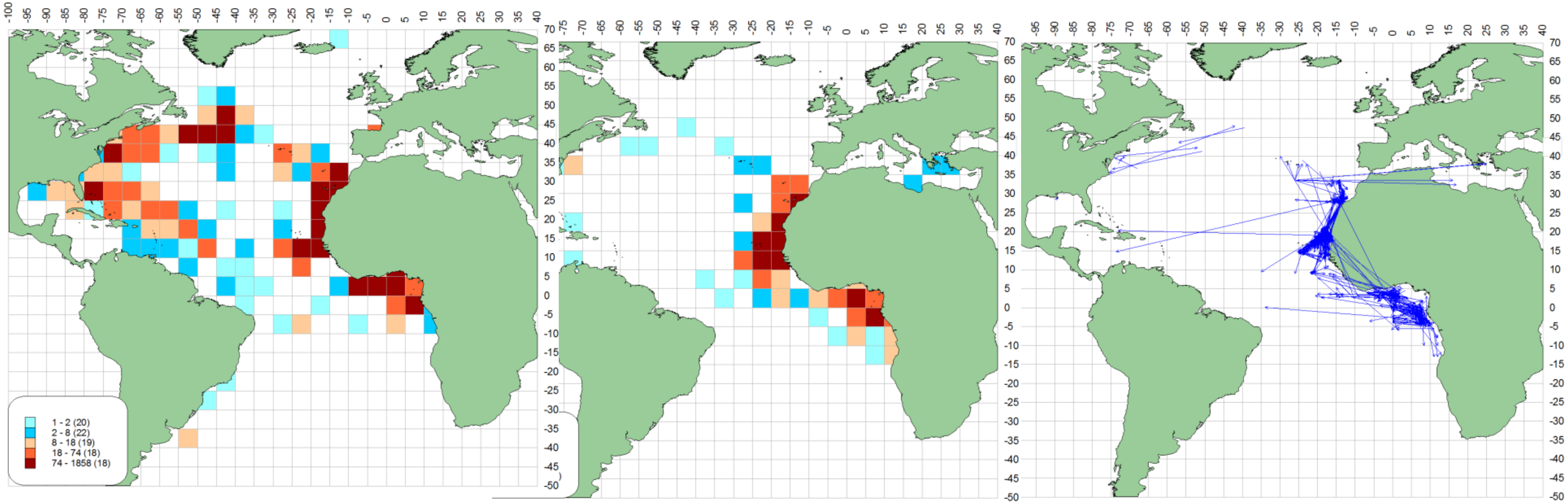


Figure 1. Flowchart describing the schedule of development, major actors (ovals), main activities (blue boxes), outputs (orange boxes).

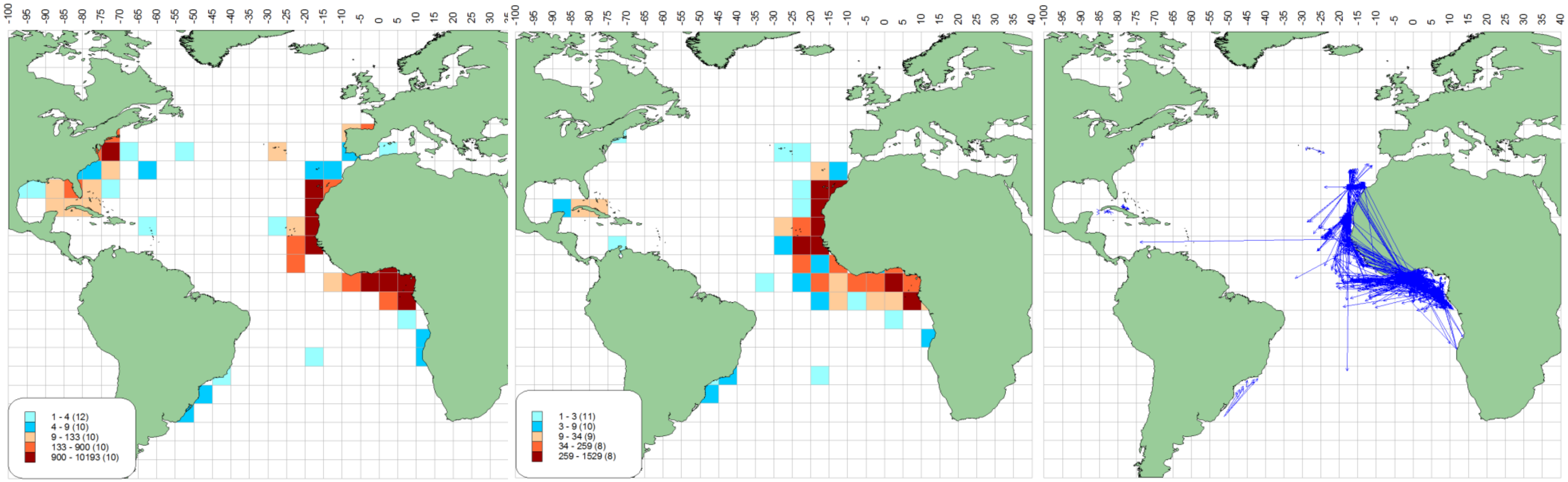


a) Density of releases.

b) Density of recoveries.

c) Straight displacement between release and recovery locations.

Figure 2. BET. Location of releases and recoveries.

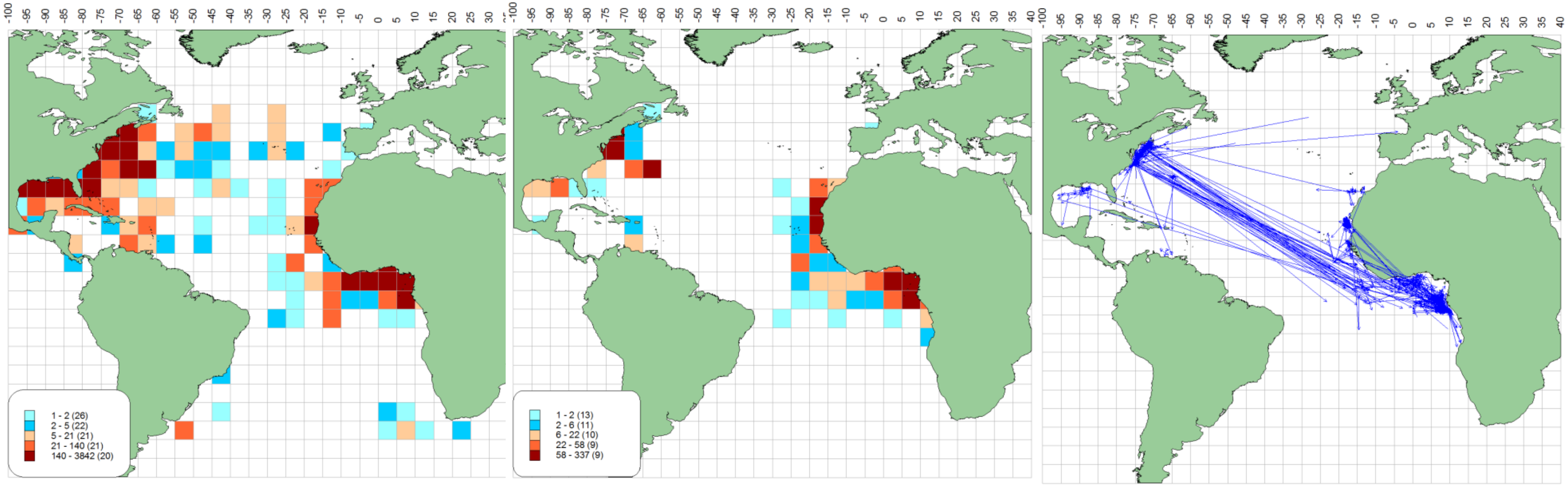


a) Density of SKJ releases.

b) Density of SKJ recoveries.

c) Straight displacement between release and recovery locations.

Figure 3. SKJ. Location of releases and recoveries.



a) Density of releases.

b) Density of recoveries.

c) Straight displacement between release and recovery locations.

Figure 4. YFT. Location of releases and recoveries.

Appendix 1

AGENDA

1. Opening, adoption of Agenda and meeting arrangements
2. Revision and update of the AOTTP prepared in 2010
   - 2.1 Revision of the AOTTP program
   - 2.2 Analyses of the IOTTP development and results
   - 2.3 Definition of new objectives and priorities
   - 2.4 Definition of the ToR for the Call for Tenders for the development of a detailed program
3. Review of current status of work conducted by the Working Group on the improvement of Ghanaian statistics.
   - 3.1 Revision and evaluation of Task II catch and effort and size data for the intermediate period considered by the group, including:
     - 3.1.1 Methods used to estimate the species composition
     - 3.1.2 Methods used to estimate catch at size data, including substitution criteria
     - 3.1.3 Methods used to incorporate “faux poisons” data
   - 3.2 Revision of activities conducted under the collaboration plan between Ghanaian and IRD scientists defined by the Tropical Species Group
     - 3.2.1 Activities on port sampling and data entry and validation
     - 3.2.2 Criteria to consider in the treatment of the most recent data (since 2006)
4. Responses to the Commission on
   - 4.1 FADs Management Plan
   - 4.2 Evaluation of the port sampling plan aimed at collecting fishery data for BET, YFT and SKJ that are caught in the geographical area of the area/time closure developed by the SCRS in 2012.
5. Recommendations
6. Other matters
7. Adoption of the report and closure

Appendix 2

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Appendix 3

LIST OF DOCUMENTS

SCRS/2013/020	Preliminary report for the data processing training course in Tema, November 2012. Damiano, A., Rojo, V. and Barrigah, S.
SCRS/2013/022	New TASK2 (catch & effort, catch at size) statistics estimated in 2013 for the Ghanaian fleet during the 1996-2005 period. Fonteneau, A., Bannerman, P., Ayivi, S. and Nordstrom, V.
SCRS/2013/026	Catch characteristics of tropical tuna caught by Korean tuna longline fishery in the Atlantic Ocean. Yoon, S.C., Kim, Z.G., Lee, S., Park, H. and Lee, D.W.
SCRS/2013/029	EU/Spain Fish Aggregating Device Management Plan. Delgado de Molina, A., Ariz, J., Santana, J.C. and Rodriguez, S.
SCRS/2013/031	A simulated capture-recapture model for estimating mortality and stock mixing rates of migratory Atlantic fishes. Lauretta, M.V.

Appendix 4

POTENTIAL SOURCE OF FUNDING FOR THE ICCAT TAGGING PROGRAM

In 2010 the SCRS proposed an Atlantic Ocean Tropical Tuna Tagging Programme (AOTTP) with an overall budget of around 11.4 million Euros during five years. Potential sources of funding of this programme remains widely uncertain today, but this funding would preferably be obtained from a combination of various funding sources and countries that are interested by the conservation of tropical tunas, for instance from: (1) the United States that has already been providing to ICCAT a special fund of $62,500 to promote this tagging program; (2) from the EU that has expressed its great interest for the realisation of this tagging program, (3) from the private sector; and (4) from other ICCAT member countries or (5) external sources (ICCAT, 2011b).

The EU appears to be the main source of potential "core funding", because of various converging causes:

- ✓ The EU Directorate General for Development and Cooperation (DEVCO) has been the main funding source of various large scale tagging programs in the western Pacific and Indian Oceans. The cost of these programs being similar to the planned cost of the ICCAT tagging program. This DG has expressed its firm interest in the conservation of fishery resources in developing countries at a regional scale in the Atlantic. The success of its two most recent tagging programs by the IOTC and WCPFC has been important for DG DEVCO, since their results are visible at an international scale.

- ✓ The EU DG DEVCO is in charge of supporting the development and sustainable growth of the ACP countries and developing states. A total of 17 ACP countries of the Lome Agreement with EU are members of ICCAT[4] and interested by the conservation and efficient management of tropical tuna resources. The importance of tuna resources for many ACP countries in both sides of the Atlantic is an additional factor for the EU to consider funding the ICCAT tagging program.

- ✓ The EU DG DEVCO will launch in January 2014 its 11th FED program (funding program) that could be used to fund the ICCAT tagging program, using funds that are targeting regional levels and development matters of general interest for several ACP countries (as in the Indian Ocean). However, this type of funding can only be initiated from formal request by several interested ACP countries send to DG DEVCO (in the Indian Ocean, the IOTC Tagging Program was launched following the request by two countries: Seychelles and Mauritius). There is no doubt that several of the ACP countries members of ICCAT have great socio economic interest for the conservation and the sustainable exploitation of tropical tunas.

- ✓ In 2011, the EU clearly supported this financing channel within ICCAT and encouraged CPCs to coordinate their efforts with EU delegations in their countries to try to mobilize the necessary funds to implement this program.

- ✓ Total cost of these large scale tagging programs are high. However, they are a necessary investment allowing improving a safe management of highly valuable resources. In fact, the cost of large scale tagging program, that should be done every 10 years, appears to be very limited compared to the value of the catches and to the results and benefits expected from a successful large scale tagging program: for instance the landing value of tropical tunas in the Atlantic during a 10 years period can be estimated at about 1,000 million Euros (based on Tokyo and Bangkok market prices 2012)..

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[4] Angola, Barbados, Belize, Cap-Vert, Côte d'Ivoire, Gabon, Ghana, Guinea Ecuatorial, Guinée Rep, Mauritanie, Namibia, São Tomé e Principe, Senegal, Sierra Leone, South Africa, St Vincent and The Grenadines, Trinidad and Tobago.

Appendix 5

REVISION OF GHANAIAN STATISTICAL FOR THE 1996-2005 PERIOD

The method and hypothesis leading to the revision of Ghanaian Task II C/E and size data that have been accepted by the Tropical Tunas Species Group as well as their results are described in detail in document SCRS/2012/022. This document also summarizes the main results that should be used to do future stock assessment for the yellowfin, skipjack and bigeye tuna stocks, and these best results are compared to the results that have been obtained using various alternate hypothesis in the data processing used to estimate corrected and extrapolated Ghanaian C/E and CAS statistics during the 1995-2005 period.

The main parameters and working hypotheses used in the data processing approved by the Group can be summarized as following:

- Total Ghanaian yearly catches by gear are identical to levels of catches submitted by Ghana to ICCAT, but assuming in 2004 a total catch of 77824 tons (instead of the ICCAT 55619 tons).
- All data processing have been stratified in 3 areas (2 coastal and 1 offshore), 2 gears (BB and PS), 3 fleets (A, P and S) and by quarter.
- Total catches by 1° square, quarter and areas of A & P fleets have been entirely estimated by strata substitution, based on the logbook data of these two fleets during the 2006-2010 period (assuming that the fishing patterns and their seasonality were identical during the two periods).
- The S-Fleet C/E and CAS statistics have been estimated independently by EU scientists as a component of the EU PS fleet, and these results have been already submitted to the ICCAT Secretariat.
- Large yellowfin and large bigeye (at sizes over 1m) have been added to the Ghanaian size samples of Ghanaian PS, in proportion of their numbers sampled each year in the EU PS FAD landings (but only for catches South of 6°N).
- Species composition has been estimated in two successive steps: (1) the yearly amount of skipjack has been first estimated from the few Ghanaian log books available each year (based on the fact that percentages of skipjack are very similar in the EU PS FAD multispecies samples and in Ghanaian logbooks); (2) the relative amount of yellowfin and bigeye in the Ghanaian catches have been estimated based on the percentages of the two species in the Ghanaian multi-species size samples (based on the hypothesis that there was no bias in the sampling of these two species).
- Catch by species and CAS of tunas landed in the Abidjan "*faux poissons*" market have been estimated and incorporated in the new Ghanaian data set of the 1996-2005 period (corresponding to an average of 1760 tons).
- Quarterly CAS of the three species has been estimated using a quarterly extrapolation of Ghanaian size samples (corrected for their missing large fishes, by gear, but without geographical area) to the total catches of each species, and adding the estimated quarterly CAS of *"faux poissons"*.
- Fishery C/E and CAS data have been estimated for the year fishing 1996 using the present method; these results should be used by ICCAT scientists, instead of the corresponding 2011 data.

The main results of these calculations are given in the **Appendix-Table 1** comparing the present yearly catches by species of Ghanaian fleet and the same information based on present results approved by the Group and in the **Appendix-Table 2** comparing the average Ghanaian catch at size of the three species used in recent stock assessment and accepted now.

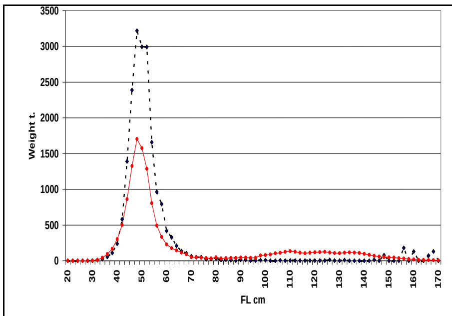
The catch-at-size (CAS) distributions obtained for the three main tropical species (YFT, SKJ and BET) are shown in **Appendix-Figure 1**.

Appendix-Table 1a. Yearly catches by species of the Ghanaian fleets (ICCAT Task I) (before correction of the 2004 catches).

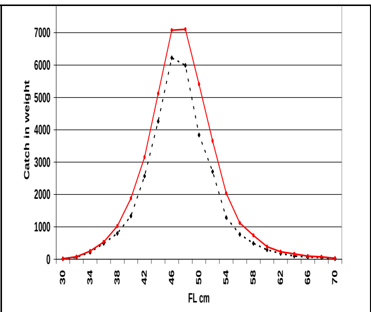
year	YFT	SKJ	BET	Total
1996	11 720	19 602	5 805	37 127
1997	15 437	26 336	9 828	51 601
1998	17 656	34 182	13 369	65 207
1999	25 268	40 215	17 763	83 246
2000	17 662	28 973	5 909	52 544
2001	33 545	42 488	12 041	88 074
2002	23 673	30 498	7 105	61 276
2003	18 457	24 596	13 557	56 610
2004	15 053	25 726	14 900	55 679
2005	17 492	44 671	13 916	76 079
Average	**19 596**	**31 729**	**11 419**	**62 744**

Appendix-Table 1b. Corrected yearly catches by species of the Ghanaian fleets (ICCAT Task I) now approved by the WG (after correction of the 2004 catches).

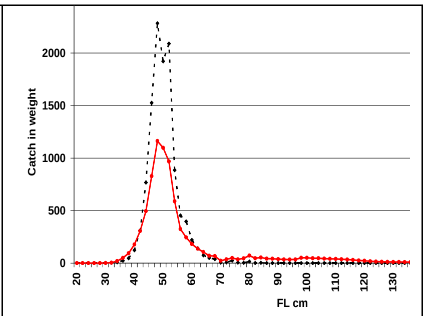
Year	YFT	SKJ	BET	Total
1996	8 182	24 205	4 751	37 138
1997	15 080	26 364	10 165	51 609
1998	13 222	41 840	10 155	65 216
1999	20 815	52 024	10 416	83 255
2000	12 304	34 980	5 269	52 553
2001	23 392	55 475	9 214	88 081
2002	18 100	37 570	5 611	61 280
2003	15 002	32 977	8 646	56 624
2004	14 044	46 030	17 744	77 817
2005	13 019	54 209	8 860	76 089
Average	**15 316**	**40 567**	**9 083**	**64 966**



Appendix-Figure 1a. Average CAS of YFT Ghanaian catches during the 1996-2005 period (dotted line: old CAS).



Appendix-Figure 1b. Average CAS of SKJ Ghanaian catches during the 1996-2005 period.



Appendix-Figure 1c. Average CAS of BET Ghanaian catches during the 1996-2005 period.

SCRS/2013/020 Collect. Vol. Sci. Pap. ICCAT, 70(6): 2546-2555 (2014)

REPORT FOR THE TUNA SAMPLING TECHNICAL WORKSHOP HELD IN TEMA, 2012 NOVEMBER 4 TO 16

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SUMMARY

As a complement to the first workshop conducted in july 2012, some additional comparative sampling operations were held in Tema with both MFRD and ICCAT sampling teams. This activity was followed by thorough checking of the database inputs (AVDTH) and associated control program reports (AKADO). Then the latest versions of AVDTH (4.1) and AKADO (4.2) were installed on MFRD computers and a training course was held to explain how to obtain wells maps from the vessels or how to elaborate reliable ones in order to follow the suitable sampling protocol.

RÉSUMÉ

En complément au premier atelier tenu en juillet 2012, quelques opérations supplémentaires d'échantillonnage comparatif ont été réalisées à Tema par les équipes d'échantillonnage du MFRD et de l'ICCAT. Un suivi de ces activités a été réalisé en vérifiant exhaustivement les données d'entrée de la base de données (AVDTH) et les rapports associés du programme de contrôle (AKADO). Ensuite, les dernières versions de AVDTH (4.1) et AKADO (4.2) ont été installées sur les ordinateurs du MFRD et un cours de formation a été dispensé afin d'expliquer la façon d'obtenir des plans des cuves des navires ou la façon d'élaborer des plans fiables en vue d'appliquer le protocole d'échantillonnage adéquat.

RESUMEN

Para complementar las primeras jornadas de trabajo realizadas en julio de 2012, se han realizado algunas operaciones de muestreo comparativas adicionales en Tema con los equipos de muestreo del MFRD y de ICCAT. Tras dicha actividad, se procedió a una comprobación exhaustiva de las entradas de la base de datos (AVDTH) y de los informes de programas de control asociados (AKADO). Finalmente, se instalaron las últimas versiones de AVDTH (4.1) y AKADO (4.2) en los ordenadores del MFRD y se impartió un curso de formación para explicar cómo obtener planos de cubas de los buques o cómo elaborar planos fiables para seguir un protocolo de muestreo adecuado.

KEYWORDS

Tuna fishery, purse seine, pole and line, statistical monitoring, species composition, length structure, imput and control applications

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1 Introduction

With the development of a purse seine fleet in the late 1990s, Ghanaian catches reported as task I to the ICCAT have been estimated at about 60.000 t to 80.000 t per year, making Ghana one of the major components of the tropical fishery operating in the Eastern Atlantic Ocean. In spite of some sampling efforts and progress obtained by Ghanaian scientists in the collection of fishery statistics, certain uncertainties and potential biases in tasks I species composition and in size distribution as well as a very low coverage for task II have stunted diagnostics in stocks assessments as well as analyses concerning the efficiency of protection plans for juveniles of tropical tunas based on time-area closures.

In order to improve Ghanaian statistics and to reduce uncertainties in stocks assessment and other analyses on tropical tunas, the Standing Committee on Research and Statistics (SCRS) of the ICCAT strongly recommended the organisation of a working group devoted to, among other issues, the improvement of Ghanaian statistics. As a consequence, an ICCAT working group on Ghanaian tuna statistics was held in Madrid in 2011 (phase II, 30 may – 3 june 2011) during which recent Ghanaian catch, effort, and size data were revised and alternative procedures to estimate past time series were proposed.

Following this working group, it has been decided to set in place a collaborative project between the IRD and Ghana in order to strengthen Ghanaian industrial purse seine fishery monitoring in the gulf of guinea. This project (Bannerman et al., 2012) was approved by the SCRS and it is included in the Tropical species 2012 work plan as addendum.

In july 2012, a preliminary mission in Tema of the sampling team took place (Damiano et al, 2012). During simultaneous sampling with MFRD team some problems were identified in the selection procedure of individual for species identification and length measurement.

This document presents the results of the training course planned within this project which took place in Tema in november 2012.

2 Objective

The objectives of this training course were:

(1) to analyze in situ the procedure followed to estimate the species composition of the tuna catch landed in Tema from multi-specific sampling;

(2) to determine whether differences detected between Ghanaian statistics provided to ICCAT and observed in other surface fisheries operating in similar conditions are real, resulting of a sampling bias, a result of a different process in processing data, or due to other causes and

(3) to check the Ghanaian 2008-2012 databases and see how they can fit to T3 for processing.

3 Operationnal work

3.1 Sampling

The structure of MFRD staff is described in the **Table 1**. The MFRD staff is split into two teams (A and B). Alternatively, for one month, each team is on duty for:

- Monitoring Panofi transshipments (at anchor in Tema harbor) and sampling
- Monitoring landings alongside quay in Tema port and sampling

Sampling schedule (**Table 2**): during the stay in Tema 4 sampling sessions were held by ICCAT and MFRD teams on the following landings:

- Rico Uno (Rico Co BB)
- Marine 707 (World Marine Co BB)
- Ace 1 (G-L Fisheries BB)
- Cap St Paul (TTV Co PS)

The comparison between ICCAT and MFRD samplings are presented in **Figures 1** to **5.** As ICCAT team was smaller than MFRD the samples held by ICCAT team were often compared to two MFRD samples but as we can see on the graphs, no significant differences in species or in size repartition were evidenced. This is confirmed by the Kolmogorov-Smirnov test result (**Table 3**) showing that there is no significate difference between YFT and SKJ size histograms. The numbers of BET, FRI and LTA fishes sampled by length intervals are quite low; consequently the tests results should be interpreted with caution.

As the species distribution observations for both teams are now very close we can suppose that the recommendations done during our previous training course in July 2012 have been taken in account and that MFRD team follows now the sampling protocol.

3.2 Database situation and description of the main problems

A) From 2008 to 2011, data have been entered with AVDTH version 3.2. It would be better to convert them into AVDTH 2010 by using the Dconvert application.

B) 2012 data are not yet entered because there is no computer available to perform this task. We strongly recommend that 2012 data be entered with AVDTH 2010.

C) The main problem observed concerns the lack of reliable logbooks and wells map. The MFRD staff explained that the captain's declarations about the identification of the wells where are stored the different sets are not reliable. It was evidenced that aboard baitboats, and aboard small Purse Seiner the catch is shifted to other wells after freezing. For instance: the first set of 25 tons is declared to be put in wells 1 PortSide and 1 StarBoard containing brine. However when the freezing temperature is reached fish is picked out from wells 1 PS and SB and put into the front hatch as dry freezing (as this hatch is not equipped for freezing in brine). The second set of 30 t is also declared to be thrown into wells 1 PS and SB but it is then moved to front hatch or rear hatch or another well, a.s., till these secondary wells are completely full. In conclusion 300 or 350 tons of each trip may be declared to be in primary wells but in fact the fish is moved to other wells.

D) Control program (AKADO) messages:
Checking the MFRD databases, the main problems encountered by the programme AKADO were the following:

Trip 1/2:

E/W	Marée			Jour départ				Jour arrivée			Distance		Séquence
-	C_BAT	Type	D_DBQ	D_DEPART	Act_J_deb	S_tm_d	S_tp_d	Act_J_fin	S_tm_f	S_tp_f	V_LOCH	S_Dist	-
W	531	BB	17/07/2012	12/06/2012	12/06/2012	24	12	17/07/2012	24	12	-	3228	-
W	642	PS	13/07/2012	27/05/2012	27/05/2012	24	12	13/07/2012	24	12	-	5360	-
W	694	PS	14/07/2012	06/06/2012	06/06/2012	24	12	14/07/2012	24	12	-	4321	-
W	787	PS	12/07/2012	21/06/2012	21/06/2012	24	12	12/07/2012	24	12	-	1053	-
W	841	PS	06/07/2012	01/06/2012	01/06/2012	24	12	06/07/2012	24	12	-	5386	-

A day-at-sea duration of 24 hours is not possible for the first and last day of a fishing trip. Consequently, departure and arrival hours must be taken into account for the computation of the exact time at sea for those days.

Trip 2/2:

E/W	Marée			Temps Mer		Temps Pêche		Poids débarqué		Départ	Captures	R.	Enquête	Echantillon		
-	C_BAT	Type	D_DBQ	TM	S_tm	TP	S_tp	V_POIDS	S_P_Lots	F_CAL_VID	S_P_Capt	-	F_ENQ	N	S_Pond	S_Poid
E	531	BB	17/07/2012	864	864	432	432	187	187	1	364 | 364	0.59	1	2	171.5	171.5
W	841	PS	06/07/2012	864	864	432	432	0	0	0	724 | 724	0	1	2	-	-

In case 1 (C_BAT=531) the landing manifest is uncompleted and as a result such situation creates an erroneous raising factor of 0.59 between the declared catch and the landed catch.

Activities

E/W	Activité					Opération	Poids			Associations		Position						T °C
-	BAT	Type	D_DBQ	D_ACT	N_ACT	OPERA	POIDS_CAP	S_capt_elem	S_pond_act	TBANC	Assoc	Q	LAT	LON	A terre	OA/OI	N_Ech	-
E	642	PS	13/07/2012	25/06/2012	2	1	21	21 | 21	19	1	24	4	223	1224	non	1	-	
E	642	PS	13/07/2012	26/06/2012	1	1	47	47 | 47	33	1	24	4	218	1218	non	1	-	
E	642	PS	13/07/2012	26/06/2012	2	1	66	66 | 66	56.5	1	24	4	225	1209	non	1	-	
E	642	PS	13/07/2012	27/06/2012	1	1	27	27 | 27	13.5	1	24	4	236	1218	non	1	-	
E	694	PS	14/07/2012	23/06/2012	1	1	65	65 | 65	32.5	1	23	4	437	557	non	1	-	
E	694	PS	14/07/2012	26/06/2012	1	1	50	50 | 50	12.5	1	24	4	404	657	non	1	-	
E	694	PS	14/07/2012	10/07/2012	1	1	30	30 | 30	15	1	23	1	220	155	non	1	-	
E	694	PS	14/07/2012	11/07/2012	1	1	40	40 | 40	20	1	24	1	224	146	non	1	-	
E	787	PS	12/07/2012	25/06/2012	1	1	22	22 | 22	11	1	23	1	532	113	non	1	-	
E	787	PS	12/07/2012	26/06/2012	1	1	41	41 | 41	20.5	1	23	1	511	54	non	1	-	
E	787	PS	12/07/2012	07/07/2012	1	1	92	92 | 92	46	1	23	1	452	57	non	1	-	
E	841	PS	06/07/2012	04/06/2012	1	1	10	10 | 10	5	1	24	4	35	256	non	1	-	
E	841	PS	06/07/2012	07/06/2012	1	1	110	110 | 110	55	1	24	3	55	1436	non	1	-	

The problems encountered concerns mainly samples weighting:

- There may be wrong inputs. For instance in line 1 the right figure must be 21 t and not 19 t, and in line 2 the right figure is 47 t.
- Since well maps are not provided by captains, the rule adopted by MFRD team when one day's catch has been split into 2 wells, is to split the catch in 2 equal parts. For instance, the catch of day (D_ACT) 27/06/2012 has been put in SB5 and SB8, but because only well SB5 was sampled 13.5 t was reported (i.e., 27/2) instead of 27 t.

It is worth noting here that the majority of errors identified by AKADO are similar. All errors identified during the training session have been explained to MFRD team and would easily be corrected in the 2008-2011 databases. A corrected version of the database (i.e. with no error reported by AKADO) will be brought for next planned meeting in Sète during the first semester of 2013. As trip documents are in Tema and there is no scan available presently, all the correction should be made in Tema

4 Recommendations

4.1 Working conditions, computer hardware and sampling tools

- MFRD staff should have an office in the Tema port for a better efficiency in survey and sampling of tuna landings.
- The computers are down and the sampling tools are now very old, so the following equipments should be available for the samplers:
    - 2 or 3 computers for entering AVDTH database
    - 1 scanner/printer
    - 4 ichtyometers
    - 6 calipers (2x 1,2m and 4x0,8m)
    - Gloves, boots, writing tablets, etc…

4.2 Database

- The 2008 to 2011 databases must be converted from AVDTH 2005(V3.2) into AVDTH 2010(V.3.3)
- The 2012 database should be computerized into AVDTH2010 application as soon as computers are available

4.3 Scanning documents

- For checking the database we need to go back to the original documents (logbooks, sampling forms, landing manifests). The documents should be scanned, grouped by trip and saved in pdf format (beginning with 2012 year and progressively going back to 2008). Each pdf document will be named as follows : PPPBBBYYYYMMDD where PPP is the landing port code, BBB the Turbobat vessel code, YYYYMMDD the date of arrival to the port for landing.

4.4 Wells maps and sampling protocol

- To improve the mapping of species catches it is very important to fit with the general sampling protocol including the communication of reliable logbooks and wells maps. This could be reached progressively. The recommendation by fleets are:

    - **TTV vessels.** Because these vessels seem to operate in a similar process as European fleets (freezing and landing with brine) we recommend to get from their captains a reliable wells plan on the model of annex 1 or to elaborate such a document from the logbook indications (catch by species and commercial category put in the different wells; the Access application TALLY developed by René Dedo in 2009 could be helpful for this task). The final objective is to sample the wells according to the usual AVDTH sampling protocol with weighting of the wells repartition.
    - **Panofi vessels.** Since the end of 2011 these vessels come to Tema harbor and transship the fish onto Panofi carreers under MFRD monitoring. We suggest that MFRD responsible persons get in touch with the company manager and obtain that the “shifting” from one well to another one should be avoided and ask for reliable wells plan.
    - **Other PS and BB vessels.** Carry on for the moment the usual sampling, considering that the vessel is one unique well (same process as BB vessels in Dakar) but try to improve progressively the logbook and the wells map.

5 Further actions

A meeting has been scheduled in the first semester of 2013 to summarize observations made on Ghanaian statistics and to establish an appropriate procedure for processing 2008-2012 data. Among other things, this important meeting should debate on the following points:

- How to remove unnecessary warnings in AVDTH and identify the causes of the main warnings in AKADO?
- How to handle the problem of the lack of wells map?
- Based on the analysis of the sampling data collected during the two ICCAT's team trips conducted in Tema in 2012, which species composition should be applied for the 2008-2011 period with the aim to correct the bias in SKJ and which type of sampling should be recommended for the future to avoid such a bias?
- How many fleet components should be considered in the Ghanaian fishery (e.g. TTV PS, Panofi PS, mixed small PS + BB)?
- Is there any spatio-temporal stratification by fishing mode in species composition and in size structure?
- Check the transfer from AVDTH to T3
- If there are specific features in the Ghanaian fishery which should be included in T3?
- Which sort of report should be produced by MFRD team in order to inform regularly the Ghanaian fishery administration about tuna activities in Tema;

Based on these considerations, the IRD team will conceive and build a specific Ghanaian processing procedure (T3) during the end of 2013, with a continuous exchange and validation with MFRD team.

6 Conclusions

This first training session planned within the IRD/MFRD/ICCAT programme has been very useful. The sampling protocol for species composition seems to be now well followed by MFRD staff and the 2008-2012 AVDTH databases will soon be corrected and available for processing. A technical workshop is scheduled to be held in Sète in 2013 for identification of adequate processing procedure.

Aknowledgement

We are very grateful for the assistance, transparency and receptiveness of these persons during our stay in Tema and in particular MFRD team. We also thank Pilar Pallares (ICCAT) and Daniel Gaertner (IRD) for orgnaizing this training course in Tema, ICCAT for its financial support, Laurent Dubroca (IRD) for his help in building the statistical graphs and Pierre Chavance (IRD) for revision and comments of the final mansucript.

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Table 1. MFRD sampling staff in Tema

Name	*Fish Selection*	*Measuring*	*Filling forms*	*Coding*	*Data entry*
Sylvia Ayivi (A) Sampl. Resp.	/	/	X	X	X
Victor Anaba (Head of A)	X	X	X	X	
Isaac Quaye (A)	X		X		
Joseph Badu Kotey (A)	X				
Bortei Weku (A)	X				
Eric Sawyer (Head of B)	X	X	X	X	X
Charles Darko (B)	X		X	X	X
Isaac Narh (B)	X				
Jacob Okoh (B)?	X				
Jones Tetteh (B)	X				/
Ebenezer Addi					X
Vlivlinyui					X
Priscilla Ankamah			X	X	X

Table 2. Description of ICCAT and MFRD sampling staff schedule

Sample on Bait Boat Rico Uno on 6/11/2012. "Dry" Landing: All wells opened										
Sam-ple	Institution	Team	Stage	DATE	Start time	End time	Fish selection	Measuring	Filling form	Comment
111	ICCAT	1	1	06/11/2012	10.50	11.27	Alain	Barrigah	Vanessa	Normal
111	ICCAT	1	2	06/11/2012	11.30	11.58	Vanessa	Barrigah	Alain	Normal
211	MFRD	A	1	06/11/2012	10.50	11.20	Quaye, Kotei, Weku	Victor	Sylvia	Normal
211	MFRD	A	2	06/11/2012	11.30	11.58	Quaye, Kotei, Weku	Victor	Sylvia	Normal
212	MFRD	B	1	06/11/2012	10.35	11.05	Darko, Narth, Okoh, Tetteh	Eric	CharLes	Normal
212	MFRD	B	2	06/11/2012	11.25	11.45	Darko, Narth, Okoh, Tetteh	Eric	CharLes	Normal
213	MFRD	A	1	06/11/2012	*10.50*	*11.20*	Quaye, Kotei, Weku	Victor	Sylvia	Tt mesuré
213	MFRD	A	2	06/11/2012	*11.30*	*11.58*	Quaye, Kotei, Weku	Victor	Sylvia	Tt mesuré
214	MFRD	B	1	06/11/2012	11.58	12.26	Darko, Narth, Okoh, Tetteh	Eric	CharLes	Normal
214	MFRD	B	2	06/11/2012	12.38	12.52	Darko, Narth, Okoh, Tetteh	Eric	CharLes	Normal
Sample on Bait Boat Marine 707 on 8/11/2012. "Dry" landing; All wells opened										
Sam-ple	Institution	Team	Stage	DATE	Start time	End time	Fish selection	Measuring	Filling form	Comment
121	ICCAT	1	1	08/11/2012	10.43	11.20	Alain	Barrigah	Vanessa	Normal
121	ICCAT	1	2	08/11/2012	11.30	11.47	Vanessa	Barrigah	Alain	Normal
221	MFRD	A	1	08/11/2012	10.44	11.13	Quaye, Kotei, Weku	Victor	CharLes	Normal
221	MFRD	A	2	08/11/2012	11.20	11.35	Quaye, Kotei, Weku	Victor	CharLes	Normal
222	MFRD	A	1	08/11/2012	11.50	12.10	Quaye, Kotei, Weku	Victor	CharLes	Normal
222	MFRD	A	2	08/11/2012	12.15	12.25	Quaye, Kotei, Weku	Victor	CharLes	Normal
Sample on Bait Boat Ace 1 on 14/11/2012. "Dry" landing; Wells 5P et 5S										
ple N°	Institution	Team	Stage	DATE	Start time	End time	Fish selection	Measuring	Filling form	Comment
131	ICCAT	1	1	14/11/2012	10.35	11.00	Vanessa	Barrigah	Alain	Normal
131	ICCAT	1	2	14/11/2012	11.30	11.50	Alain	Barrigah	Vanessa	Normal
231	MFRD	A	1	14/11/2012	10.35	10.55	Quaye, Kotei, Weku	Victor	CharLes	Normal
231	MFRD	A	2	14/11/2012	11.30	11.45	Quaye, Kotei, Weku	Victor	CharLes	Normal
Sample on Purse Seiner Cap St Paul on 14/11/2012. "In brine" landing; Wells 4P, 4S, 5S										
Sam-ple	Institution	Team	Stage	DATE	Start time	End time	Fish selection	Measuring	Filling form	Comment
141	ICCAT	1	1	14/11/2012	13.10	14.08	Vanessa	Barrigah	Alain	Normal well 4P
141	ICCAT	1	2	14/11/2012	14.10	14.27	Alain	Barrigah	Vanessa	Normal well 4P
241	MFRD	A	1	14/11/2012	13.20	13.40	Quaye, Kotei, Weku	Victor	CharLes	Normal well 4S
241	MFRD	A	2	14/11/2012	14.05	14.45	Quaye, Kotei, Weku	Victor	CharLes	Normal well 4S
242	MFRD	A	1	15/11/2012	10.10	10.22	Quaye, Kotei, Weku	Victor	CharLes	Normal well 5S
242	MFRD	A	2	15/11/2012	11.00	11.40	Quaye, Kotei, Weku	Victor	CharLes	Normal well 5S

Table 3. Kolmogorov-Smirnov test result

samples id	YFT	SKJ	BET	ALB	LTA	FRI
111 vs 211	ns	ns	NA	NA	ns	ns
111 vs 212	ns	ns	NA	NA	ns	ns
213 vs 214	ns	*	NA	NA	NA	ns
121 vs 221	*	ns	NA	NA	NA	ns
121 vs 222	*	ns	NA	NA	NA	ns
131 vs 231	*	ns	NA	NA	NA	ns
141 vs 241	ns	ns	NA	NA	NA	ns
141 vs 242	*	ns	ns	NA	NA	ns

Ns : no significative difference between size histogram
* : significative difference betweeb size histogram (two sample Kolmogorov-Smirnov tests with p value < 0.05)
NA : no or not enough data (ie fishes number less than 10 for the two samples)

The numbers of fishes sampled by length intervals are quite low consequently the tests results should be interpreted with caution.

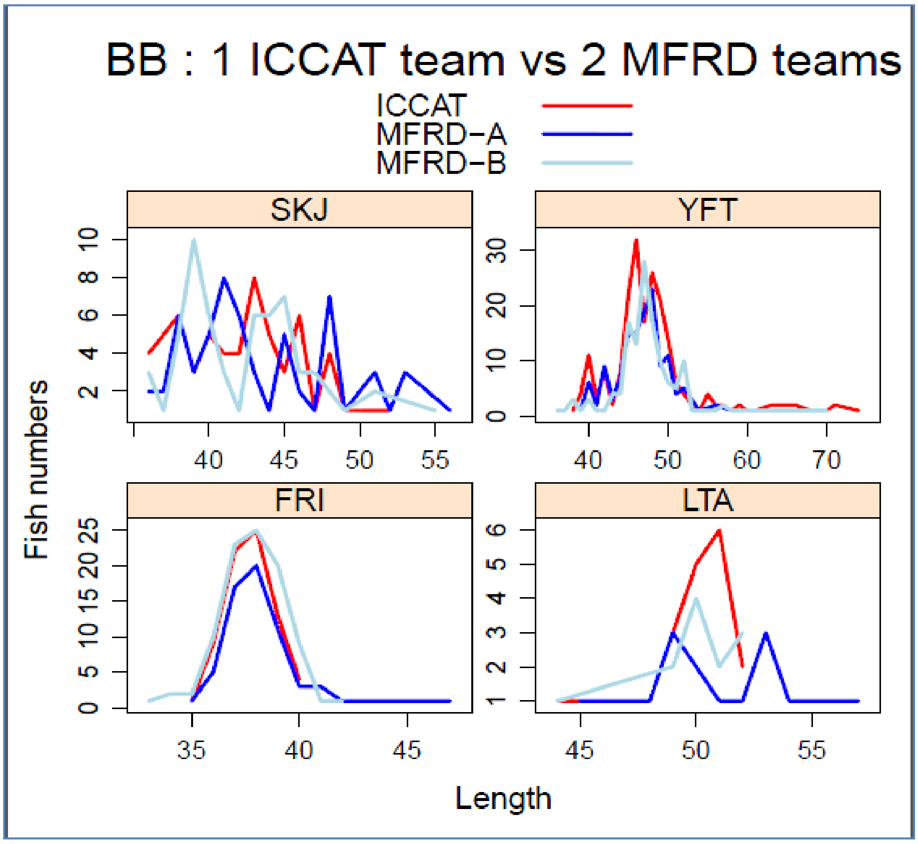

Figure 1. Bait Boat : ICCAT sample 111 Vs MFRD 211 and 212

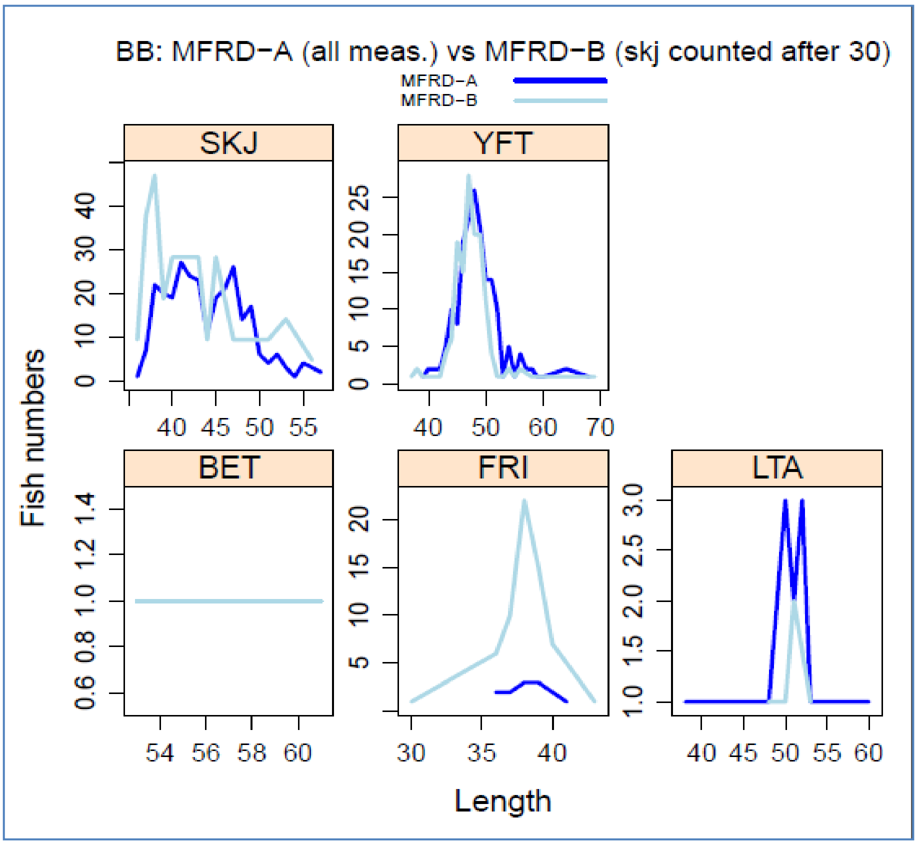

Figure 2. Bait Boat : MFRD sample 213 Vs MFRD 214

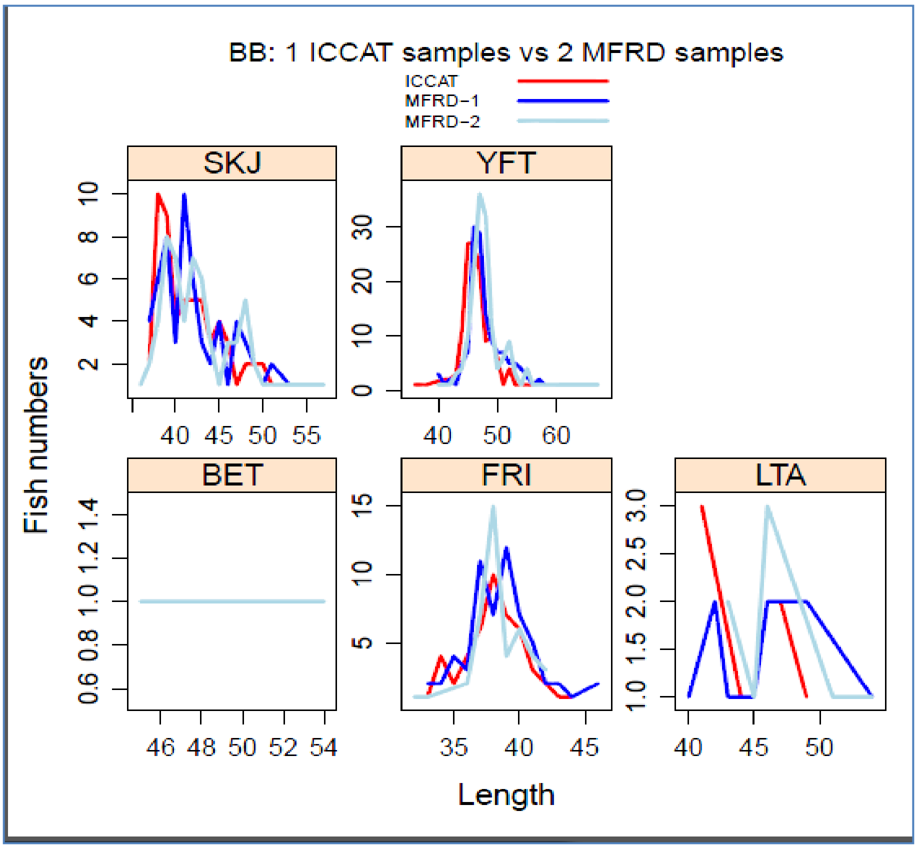

Figure 3. Bait Boat : ICCAT sample 121 Vs MFRD 221 and 222

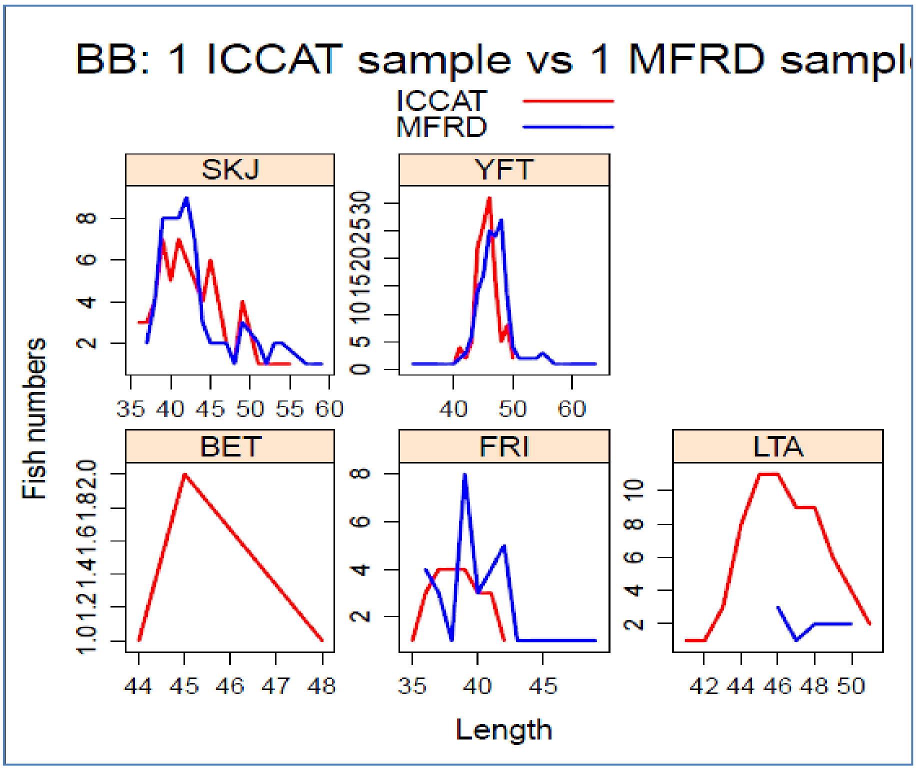

Figure 4.Bait Boat : ICCAT sample 131 Vs MFRD 231.

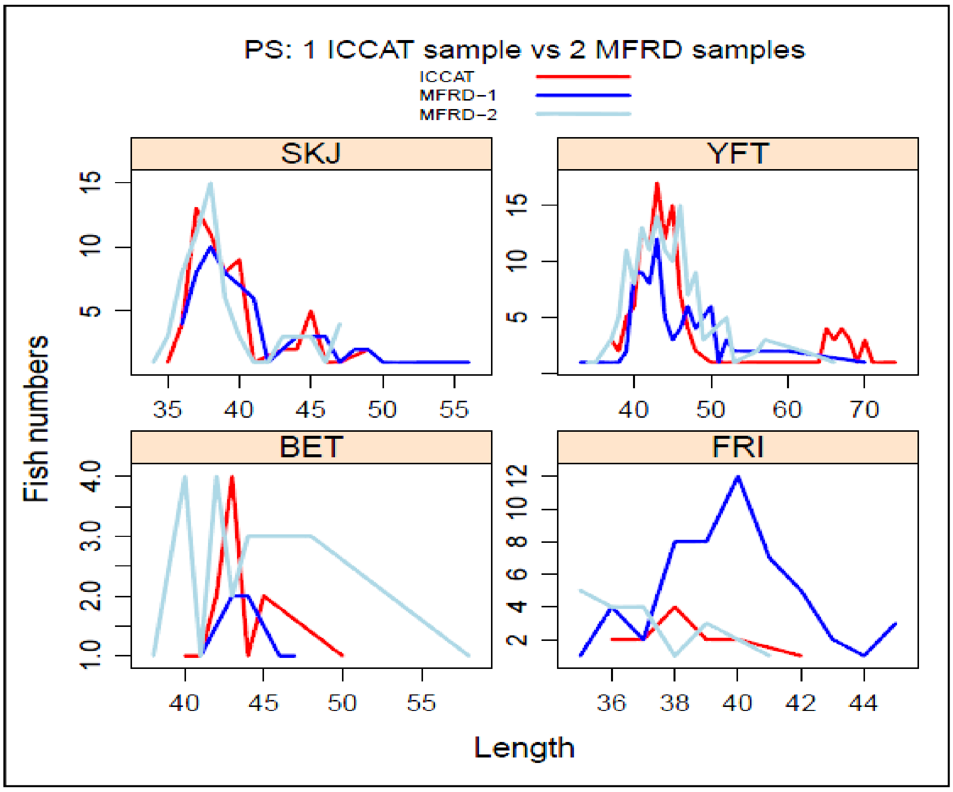

Figure 5. Purse seiner : ICCAT sample 141 Vs MFRD 241 and 242.

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NEW TASK2 (CATCH & EFFORT, CATCH AT SIZE) STATISTICS ESTIMATED IN 2013 FOR THE GHANAIAN FLEET DURING THE 1996-2005 PERIOD

By Fonteneau[1] Alain, Paul Bannerman[2], Sylvia Ayivi[3] and Viveca Nordstrom[4]

SUMMARY

This paper describes the data, method and hypothesis proposed to estimate an optimal TASK2 (catch & effort and catch at size statistics) for the Ghanaian fleet during the 1996-2005 period. It makes a review of the various results, pending questions and problems in the data available and in the sampling process. These uncertainties are discussed and an optimal data processing scheme is proposed. Various types of stratification and of statistical hypothesis are compared. A base case optimal data processing and its results are proposed by this study. This new data processing basically uses the log books and size samples done on the Ghanaian fleet but also the species composition of FAD catches sampled in the EU PS fleet. The adult BET and YFT that are always caught by EU PS, but most often missing in the Ghanaian samples until 2007 have been added to Ghanaian samples. This paper also discusses the changes in TASK1 & TASK2 (C/E & CAS) due to this new data processing. A preliminary data processing has been also done for the 2006-2010 data and its results are proposed for discussion.

RÉSUMÉ

Ce document décrit les données, les méthodes et les hypothèses proposées pour estimer la Tâche II de manière optimale (statistiques de prise et d'effort et de prise par taille) de la flottille ghanéenne pour la période 1996-2005. Il passe en revue les différents résultats, les questions restées en suspens et les problèmes entourant les données disponibles et survenus lors du processus d'échantillonnage. Ces incertitudes sont abordées et un système optimal de traitement des données est proposé. Plusieurs types d'hypothèses statistiques et de stratification sont comparés. Un système optimal de traitement des données du scénario de référence et ses résultats sont proposés dans la présente étude. Ce nouveau système de traitement des données utilise principalement les carnets de pêche et les échantillons de tailles provenant de la flottille ghanéenne ainsi que la composition par espèce des prises échantillonnées réalisées sous DCP par la flottille de senneurs de l'Union européenne. Les spécimens adultes de thon obèse et d'albacore qui sont toujours capturés par les senneurs de l'Union européenne, mais dont la plupart font souvent défaut dans les échantillons ghanéens jusqu'en 2007, ont été ajoutés aux échantillons ghanéens. Le présent document se penche également sur les changements de la Tâche I et de la Tâche II (prise/effort et prise par taille) découlant de ce nouveau système de traitement des données. Un traitement provisoire des données de 2006-2010 a également été réalisé et ses résultats sont soumis à la discussion.

RESUMEN

En el documento se describen datos, métodos e hipótesis propuestos para mejorar las estimaciones de Tarea II (estadísticas de captura y esfuerzo y de captura por talla) para la flota ghanesa durante el periodo 1996-2005. Se realiza una revisión de los diferentes resultados, cuestiones pendientes y problemas en los datos disponibles y en el proceso de muestreo. Se debaten estas incertidumbres y se propone un esquema de procesamiento de datos óptimo. Se comparan varios tipos de hipótesis estadísticas y de estratificación. En este estudio se proponen un sistema procesamiento de datos óptimo del caso base y sus resultados. Este nuevo sistema de procesamiento de datos utiliza básicamente los cuadernos de pesca y las muestras de talla recogidas en la flota de Ghana, pero también la composición por especies de las capturas con DCP muestreadas en la flota de cerco de la UE. El patudo y el rabil adulto que está siempre presente en las capturas de cerco de la UE, y que está a menudo ausente en las muestras de Ghana hasta 2007, se añadieron a las muestras de Ghana. En el documento se

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debaten también los cambios en Tarea I y Tarea II (captura y esfuerzo y captura por talla) debidos a este nuevo sistema de procesamiento de los datos. Se llevó a cabo también un procesamiento de datos preliminar para el periodo 2006-2010 y sus resultados se presentan para debate.

KEYWORDS

Ghana, tuna, statistics, species composition, tuna sizes

1 Introduction: main goals of this work

This work is a follow up of the work done by the ICCAT WG in 2011 and subsequent work done by scientists (Ghanaian & EU) following this 2011 meeting. Its goal is to build a set of methods and hypothesis allowing to estimate optimal TASK1 and TASK 2 (catch & effort and catch at size statistics) for the Ghanaian fleet during the 1996-2005 period. The goal of this work is to create realistic TASK2 series for the Ghanaian fleet that can be used in future ICCAT stock assessments of YFT, SKJ and BET. This work first makes a review of the various pending questions and problems in the data available and in the sampling process since the 2011 WG, and it proposes potential new methods allowing to estimate this TASK2 using a combination of Ghanaian and EU PS statistical data. The 2013 WG will have a full opportunity to examine and discuss these results and hypothesis, and if necessary, to estimate the results of alternate data processing that could be done during the 2013 WG based on alternative hypothesis. This work will be solely targeting the catches and catches by size of the 3 major tuna species, YFT, SKJ and BET, and it will not try to estimate the quantities and sizes of small tunas landed by Ghanaian vessels, because these secondary species are poorly followed and very difficult to estimate, when these data have never been used by SRCS to do stock assessment analysis.

2 Some basic results, facts and questions on Ghanaian statistics and fisheries

2.1 Overview

The WG organized in 2011 by ICCAT on the Ghanaian statistics made a comprehensive analysis of the data analysis and statistical questions that should be used & took into consideration in the creation of the realistic TASK2 (C/E & sizes). The 2011 WG was not in position to estimate such realistic TASK2 because of several serious problems that were identified but without a clear solution during this 2011 WG.

The first year of this statistical series, the year 1996, has been already estimated by the 2011 WG, but because of the wide uncertainties in the statistics of this important year (a catch of 37.000 t.), its C/E & CAS statistic have been again estimated following the new working hypothesis used for this period. The WG will have the choice to choose the 2011 or 2013 results as being the best ones that should be used for this year 1996 in its future stock assessments.

2.2 Species composition

The 2011 WG for instance showed that the species composition presently estimated for Ghanaian catches was widely questionable, for instance always showing very low proportion of skipjack, a result in total contradiction with many observations done on the Ghanaian catches in Abidjan and at the MW-Brands cannery and on the species composition always observed on the FAD catches of EU PS.

This structural heterogeneity of species composition is well summarized by figures 1 and 2 (from the 2011 WG).

A very important factor that was noted during the 2011 WG was that **the species composition of Ghanaian catches (TASK1 & CAS) was totally and solely conditioned by the species composition of the Ghanaian samples (in weight):** the percentage of each species in the catch being calculated by the ICCAT secretariat, but without any stratification by size category or by time and area strata or gear. More importantly, this species composition was assuming a constant perfect randomness in the multispecies sampling done in Tema. Thus the present species composition of Ghanaian catches is totally conditioned:

- by the often quite low rate of Ghanaian size sampling
- by the full randomness of the fish selection sampling: each sampled fish should have the same probability to be sampled or counted by scientists, independently of its species and its size or of the unloading process (without pre-selection of sampled tunas by samplers)
- by the inadequate data processing of this non stratified species composition.

These unsolved major questions related to the species composition of Ghanaian landings had hampered the 2011 WG to estimate a realistic species composition. Subsequently, various new sampling experiments have been done in 2012 by EU and Ghanaian scientists to at least control the validity & randomness of the Ghanaian sampling.

The main conclusion of these experiments (Damiano et al July 2012) was that there was a structural bias in the selection and randomness of the tuna measured and counted in the Ghanaian sampling process, this bias producing an underestimation of SKJ catches. It should also be noted that this non randomness of the Ghanaian size sampling was already well identified and analysed by Alain Hervé 2003 in his report to ICCAT. However, it has been noted that Ghanaian samplers are very efficient to identify the small BET, even at small sizes and frozen. It remains unknown at which date this full efficiency has been reached by the Tema samplers?

However, when the SKJ sampling bias has been accepted, it is now very interesting to estimate the ratio of BET quantities vs (YFT+BET), i.e. the % of BET in the catches of **"major tunas without stripes"**. This parameter has been estimated from the various sources of sampling and for various fleets (Ghana & EU PS, Ghanaian BB & PS), see **Figure 3.**

Keeping in mind that small BET was already well identified in the EU PS catch sampling since 1980, this figure would indicate that the increasing percentage of BET in Ghanaian samples was probably due to two factors: (1) a real increase in BET percentage in the catches (as shown in the EU PS samples) and (2) to an increased capacity of Ghanaian samplers to identify small BET. This figure would also indicate often a lower percentage of BET in the Ghanaian samples than in the EU PS catches, probably due to their more coastal fishing zones (where BET is less abundant, see **Table 6**).

Furthermore, there is also an additional clear bias in the lack of very large YFT & BET in the Ghanaian samples of the purse seine catches , during many years (cf paragraph 2.4).

As a consequence, it has been decided that all the new data processing of the 1996-2005 period should be done using 3 alternate hypotheses:

1) Using the **hypothesis H1** that the real species composition of Ghanaian catches was identical to the EU PS FAD catches (but stratified by time and area) and (2) that Ghanaian PS also have been catching large YFT & large BET, as EU PS on FADs. This hypothesis that Ghanaian & EU purse seiners fishing of FADs in the same strata are catching tuna schools with identical species and size composition may still be questionable[5], but we have no other alternative to estimate this basic statistical parameter. The size distribution of the Ghana sampling will be conserved for all tunas measured at size <1 meter, but the species composition of these catches will be driven by EU PS on FADs, and large fishes will be added in the Ghana samples when they are missing.

2) Using an alternate **hypothesis H2**, assuming that the % of SKJ caught by Ghanaian vessels was identical to the % of SKJ on FAD schools (stratified by time and areas, but that the proportion of BET sampled by scientists on the Ghanaian catches of YFT+BET was unbiased and representative of the true proportion of the 2 species in the landings of BB and PS (this rule being applied after adding the big BET & YFT to the catches of each gear, big fishes that are assumed to be missing from the Tema samples, see paragraph 2-4, using the same procedure as in the working hypothesis 1). In this hypothesis 2, the species composition of Ghanaian will be assumed to be identical all year round and everywhere, due to the high rate of samples that are poorly documented, but keeping a 2 gears stratification between for BB & for PS (see paragraph 2-8)

[5] Species composition of FAD sets may for instance be conditioned by setting times, as the early morning sets (the majority of EU FAD sets) could produce a catch showing different species composition than FAD sets done in the afternoon, due to the differential behaviour of each tuna species.

3) Using a **third hypothesis H3**, assuming that the percentage of SKJ caught by Ghanaian vessels was correctly identified identical in the Ghanaian log books, when the relative quantities of BET and YFT are estimated as in H2, the justification for this hypothesis H3 being examined in paragraph 4.8.

2.3 FAD and free school catches

The 2011 WG also discussed the free schools and FAD catches in the Ghana fishery: it is well known, based on the EU PS catches, that FAD and free school catches are most often producing widely different species and size composition (free school catches show a majority of large YFT). The information available on the Ghanaian landings would indicate that most/all Ghanaian catches during the 1996-2005 period were caught showing the typical profile of FAD catches. This conclusion is well based on the absence in the samples of pure YFT (large size), that are widely dominant in the free school fishery in the Gulf of Guinea (**Figure 4**). The rarity of free schools sets could also be easily identified in the log books: when set by set data are well recorded in the log books, all the sets with pure large YFT that have been typically done on free swimming schools are easy to identify. Only 20 of these sets of pure YFT that can be estimated as being free schools sets, can be identified in the 2006-2010 Ghanaian log books. This rarity of free school fishing could possibly be explained by the difficulty for the Korean skippers to catch these highly mobile schools of pure large YFT. However, it should be kept in mind for the future data processing of Ghanaian statistics that free school catches may have been increasing in recent Ghanaian landings due to a commercial pressure by the MW BRANDS cannery (large YFT being more frequently noticed in the recent catches of their PS). This tendency should be well analyzed in the recent log books of PS belonging to the PIONEER cannery.

2.4 Catches of large YFT & large BET by the Ghanaian fleet?

The analysis of Ghanaian size data by the 2011 WG has shown that catches of large YFT and of large BET over 1 meter are most often/always absent from all the Ghanaian size sampling in Tema. On the opposite, they have been most often sampled in the EU PS landings of FAD associated catches, and on the 5308 samples done on the EU PS FAD catches during the 1996-2005 period, 59% of these samples had at least 1 large YFT or more in these samples: these large tunas are caught in small numbers, but they are typical of FAD catches caught by PS, and they are significant in weight. These large YFT have been also frequently noticed in the sampling of Ghanaian landings in Abidjan and they have also been frequently registered at the MW Brands during recent years. They are also well sampled in the Ghanaian size samples done since 2009, but not in the scientific samplings of the period 1996-2005. This lack of large tunas in the historical sampling was probably due to a bias in the sampling process done in Tema until 2007: the 2011 WG identified this bias as being due to the fact that these large tunas were measured in predorsal length or LD2 (as in the EU PS landings), but that these data have not been computerized or not converted to fork length (it would appear now that these LD1 size samples have been lost).

In this context, we have to assume that small numbers of large YFT and large BET have also been caught by Ghanaian fisheries during this 1996-2005 period, for instance in a proportion similar to the EU FAD fishery. During the years 1996-2005, these catches of large tunas will be estimated from the EU PS FAD catches on an average yearly scale, and not quarterly, taking into account that there is a marked inter annual variability of the percentages of these large YFT, but no visible seasonality in these catches, see following **Figure 7**.

This addition of large tunas in the Ghanaian size samples is important, because adding small percentages of these large YFT (about 1.4 % in numbers) in the CAS widely reduces the catches of small individuals, in proportion to the significant weight of these large individuals.

2.5. Abidjan sampling of Ghana vessels in 2001-2004

Sampling of Ghanaian landings done in Abidjan during the 2002-2004 periods: most of the Ghanaian vessels landed in Abidjan during this period, due to an economical crisis in Ghana. During this period many of the landings have been well followed (log books and species/size sampling) by IRD/CRO scientists, and these data have been fully validated in the AVDTH data base. The rates of log books collected on these Ghanaian landings in Abidjan were higher than the log book coverage in Tema. This independent data set also covers the beginning of the P-fleet in July 2003, and it offers a valuable independent data set: in term of species and size composition, this random sampling of the Ghanaian catches was identical to the sampling of the EU fleet.

As an example, this quite intensive sampling, done under the EU PS rules of random sampling, would indicate that PS catches contains significant % of large YFT and large BET > 1 meter, these large tunas being more rarely sampled in the BB catches (see **Figure 8** and **Table 1**).

This Abidjan sampling would indicate that the percentages of large tunas were variable in 2003 & 2004, and that pole and line vessels have been also landing large tunas, but in a much lower proportion compared to PS.

Furthermore, it should be noted that the size sampling of the Ghanaian fleet done in Abidjan in 2001-2004 has been quite intensive, allowing to sample 45.100 tunas. The size composition of these ABJ samples appear to be quite similar to the EU PS FAD catches during this period, and quite different from the Tema multispecies sampling (see **Figure 10**).

2.6 Size sampling available during the period and its potential use in the estimation of quarterly CAS

It was noted during the 2011 Ghana WG that a quite good level of size sampling have been done on the 3 species landed by Ghanaian vessels (mainly in Tema, secondarily in Abidjan) during the 1996-2005 period. The total number of tunas sampled each year by gear and species are shown by **Table 2**.

In the estimation of Ghanaian CAS, the following recommendation by the 2011 WG that, *"Due to the observed seasonal variations in size frequency, it is important to calculate catch at size at the quarter level, at least, whenever possible"*, should be kept in mind and accepted in the processing of the 1996-2005 data because quarterly sizes sampled during the period are clearly showing for YFT & BET (but not for SKJ) the typical seasonality of size caught, see **Figure 11**, that was analyzed by the 2011 WG during recent years (after 2005).

The extrapolation of sampled sizes has been made in order to estimate the quarterly CAS of each species. The following working hypothesis has been used in the present data processing:

(1) Large YFT and large BET are first added in the PS samples (as described before)

(2) All the quarterly samples by gear of the 1996-2005 period are extrapolated, to the quarterly catches by 5° squares, by species, the area stratification with 3 strata being used in this calculation.

(3) Sizes of faux poissons landed in Abidjan estimated by the Abidjan sampling have been added to these CAS.

However, it can be noticed that the numbers of available samples are quite small during some quarters (cf **Table 4**), and that it may be better to extrapolate the average profiles of quarterly sizes sampled during the entire average period 1996-2005.

2.7 Spanish purse seiners fishing under Ghanaian flag: S-fleet

The total yearly catches and average fishing zones of this fleet during the period are given in the following **Figure 12** and **Table 3.**

The available task2 data of these 2 vessels (C/E & CAS) have been already processed by EU scientists and already submitted to the ICCAT secretariat for the 1996-2005 period. These vessels are showing a fishing more or less similar to the EU fishing mode, in a very large fishing zone, and not as in the Ghanaian fishing mode (conditioned by the Korean skippers of Ghanaian vessels). This point is also well shown by the high percentage 33% of free schools catches observed in this segment of the fleet.

As a consequence, the data processing of these vessels has been done using the EU T3 software and data base (and its strata substitution with other EU PS data), and independently of the main Ghana/Korean segment of the fleet. A pending question: it is not clear if these catches should be added to the Ghana TASK1 or if they are already included in the data submitted by Ghana to the ICCAT.

2.8 Small tunas sold as "Faux poissons" in Abidjan

These quantities of the 3 species of major tunas have been well estimated by CRO & EU scientists, and they have been already submitted to the 2011 Ghana WG. These tunas must be incorporated in the new TASK2 (catches and sizes), but the time and area strata of these catches cannot be estimated.

A pending question: it is not clear if these catches should be added to the Ghana TASK1 or if they are already included in the data submitted by Ghana to the ICCAT.

For simplicity reasons, they will be simply added to the total catches. These cryptic catches of major tunas are quite moderate during the processed period (an average total catch of only 1550 tons), but they are much more important during the 2006-2010 period (an average catch of 5 500 tons).

2.9 Pole and line and purse seine stratification?

The Ghana 2011 WG made a recommendation that BB & PS catches and sizes should preferably be pooled without using the traditional stratification between these 2 gears statistics, primarily because of the limited data set available.

"For the third period (1997-2010), Ghanaian catches increased to represent nearly 20% of total catches of Atlantic tropical tuna. Because of the cooperative fishing activities and sharing of catches among Ghanaian purse seine (non-PS_Other) and baitboat vessels, these must be treated during this period as if they were a single gear".

This sharing/exchange of tunas between BB and PS was already well described by Bannerman & Bard 2002 & by Alain Hervé in their report to the ICCAT Secretariat.

However it should be kept in mind that most BB and PS fisheries tend to show during the studied period a widely distinct size selectivity for large size YFT & BET: large YFT and large BET being easily caught by PS, and very rarely by BB, & especially BB that are not equipped to catch large tunas (as in Dakar and in Canary Islands). This conclusion has been well confirmed by various size sampling, for instance the unbiased Abidjan sampling in 2001-2004, showing for Ghanaian purse seiners **32%** of YFT catches in weight larger than 1 meter, and only **6 %** of large YFT for baitboats (**Figure 8**). This heterogeneity of tuna sizes landed by the 2 gears during this period is a strong proof that the exchange of tunas between these 2 gears was quite limited, as otherwise, size distribution of tunas landed by the 2 gears should have been identical.

Furthermore, most multispecies size sampling done on Ghanaian BB & PS are often showing during the 1995-2005 period a distinct species composition of the 2 gears, for instance lower rates of BET in the BB samples (see **Figure 14 a & b**). This lower rate of BET should be considered as being potentially realistic, as BET was very well identified by Ghanaian samplers during recent years. This lower rate of BET could also be exaggerated by differences in fishing zones (being a logical consequence of their more coastal fishing zones with a lower % of BET), this point being well handled by the geographical strata. A selectivity/behavioural bias, each species potentially showing a variable catchability to the shallow live bait, could also explain the lower rate of BET in often observed for BB.

In this context, the use of a combined gear BB+PS during the period 1996-2005 may introduce a bias in the estimation on the sizes & species caught by Ghanaian vessels. This problem would disappear when the BB are simply working as freezers for the PS fleet (and not as fishing vessels; in this hypothesis, all landing from Ghanaian BB & PS should show very similar or identical sizes and species composition (on the opposite, this homogeneity of the PS & BB landings, sizes and species composition, will not be visible during recent years for instance in the 2011 samples).

As a consequence, it could be concluded that stratification between BB & PS should preferably be kept in the data processing during this period 1996-2005. Furthermore, the increasing percentages of the PS catches in the Ghana landings during the 1996-2005 period, see **Figure 13**, could introduce some unexpected bias in the results, if the 2 gears are not randomly sampled in proportion of their catches[6] and later combined in the data processing. Consequently, this 2 gears hypothesis has been kept as a base case in the present data processing but an additional data processing combining the 2 gears will also done as an alternate method.

However, it should be noticed that these differences in species and in size composition of BB & PS tend to disappear during recent years, for instance during the 2008-2011 period, and during the 2006-2012 period the working hypothesis of combined gear would probably be the only hypothesis to consider in the data processing.

[6] For instance when the P-Fleet fleet of purse seiners is not sampled

2.10 1996-2005: a period of very low of log book coverage:

The yearly coverage of the log book data by 1° squares & month (ratio of log book catches and of total catches) and the percentage of catches sampled for their sizes is given by **Figure 16.** The average coverage of these log books is much lower than 10 %, rates, increasing sharply in 2003 & in 2004 (because of log books collected in Abidjan), in 2006, and after 2008.

It should be concluded that the very low average level of log books coverage, lower than 10% during most years, does not allow doing realistic extrapolations of the monthly task2 catch & effort by 1° or 5° squares, month or quarter. Furthermore, this low coverage is unevenly distributed over time: some months/quarters do not have any log books. Consequently, it has been concluded that the best & only way to estimate a realistic task 2 during this period would be working under a strata substitution hypothesis with recent years (as during the previous period 1973-1995): for instance assuming that the C/E quarterly pattern of catches by 1° was observed each year during the 1996-2005 period were identical to the fishery pattern observed during recent years, for instance during the average period 2006-2010.

2.11 A basic stratification between P-fleet & A-fleet

The Ghana 2011 WG has shown that the Ghana fleet should preferably be stratified in these 2 fleets that are showing widely different fishing zones, catch rates and percentages of well filled log books: (1)PANOFI or P-Fleet& (2) the rest of the Ghanaian fleet or A-Fleet. The P-fleet has been showing during the studied period a very low coverage of its log book and seldom landings of its purse seiners in Tema, the opposite for A-fleet with a quite good log book coverage and frequent landing/sampling in Tema during recent years. The P-fleet started its activities in 2003, and its has been quite well sampled in Abidjan in 2003 and 2004 during its 2 first year of activity (log books and size/species composition).

The yearly ratio of P-fleet log books available /P-Fleet declared catches is shown by the following **Figure 17** (also taking note that during various quarter of some years, there are few or no P-fleet log books available during the 2004-2008 period, see **Figure 18**).

The quarterly fishing zones of these 2 fleets are given by 1° squares in **Annex 1**.

Because of the low coverage of log books data of the P-fleet, and because there are no log books available during several quarters of this period (see annex 1), the C/E and CAS of this fleet will be estimated by strata substitution based on the average pattern of catch and effort during its period 2006-2010 of improved sampling. However, because of the time heterogeneity in the P-fleet log book coverage, and because of its low rate of coverage , see **Figures 17, 18 & 19**, a constant quarterly catch has been assumed for each year (at 25% of the yearly catches) for the P fleet. Its fishing zones exploited during each quarter have been assumed to be identical, based on their yearly average fishing zones during the period 2003-2010. This quite questionable statistical rule has been chosen taking into account the weakness of log book data of the P-Fleet and because of the apparent lack of seasonality in its fishing zones, well shown by the quarterly catches identified in the available log books of this fleet, see **Figure 20.**

The log books of the A-Fleet, BB & PS, have been better sampled by scientists during recent years 2006-2010 (see **Figure 16**). Their C/E data of the 1996-2005 period will be processed without strata substitution with the P-fleet, but basically doing for this A-fleet a strata substitution with the average quarterly catch and effort pattern well observed during the 2006-2010 period: assuming that the C/E by time and area strata of the A-Fleet was identical to the C/E scheme observed during this period. This seasonal pattern of quarterly fishing zones of the Ghanaian A-fleet is shown by **Figure 21**.

3 Data and methods

3.1 Basic data available and used in this work.

Seven sources of information and data bases have been used at various degrees in this work:

1) Catch and effort during the 1996-2010 period: catch and effort data corresponding to the sampled fraction of the Ghanaian fleet, by 1° and month, submitted to the ICCAT by Ghana in 2011. C/E data of 2006 and 2008-2010 have been entered in the AVDTH software and processed by the TT Ghana 2011 WG

2) Size data: unraised size samples submitted to ICCAT by Ghana in 2011 (1972-2010) and size data of the Ghanaian landings done in Abidjan during the 2001-2004 period.

3) Catch and effort and size data sampled on Ghanaian vessels in Abidjan during the 2001-2004 period (entered in the AVDTH IRD data base)

These two sets of size sampling have been cumulated by species and quarter, and the **Table 4** summarizes the numbers of tunas sampled for size in the data base.
It can be noted that the quarterly sizes by species by gear of this sample is quite consistent over time, most quarters being quite well sampled, especially taking into account the fact that these fishes are predominantly caught in a limited ranges of small size fishes.

1) Gure Campolibre & Bermeo Tarak 4, later called S-Fleet (2 vessels owned by Spanish owners & fishing under Ghana flag): detailed C/E and size data have been provided to ICCAT by IEO Spanish scientists & processed by EU scientists during the 1996-2005 period

2) Data on the yearly landings and sampling of Ghanaian "faux poissons" landed from Ghanaian vessels on the local market in Abidjan, provided by IRD/CRO to the ICCAT.

3) Monthly & yearly catches declared by Ghana for its P-fleet since 2003.

4) EU purse seiners: 2 sets of data were available and used in this study: (1) all the detailed sampling data ("SPECIES" file: by sample, by fishing mode, with the exact fishing date and position) and (2): the processed extrapolated size samples of the same fleet, extrapolated to the best catch at size of each species (by quarter and by 5°-month), after the ad hoc strata substitutions done by the IRD T3 software..

This work will be using the report of the 2011 ICCAT WG on Ghanaian statistics, and the 2012 reports by the EU scientists following there sampling experiment in Tema.

3.2 TASK 1 Used in the analysis

The present work will be done in the hypothesis that the total yearly catches of tropical tunas declared by Ghana to ICCAT for the 1996-2005 period were basically correct, but not their species composition. However the total catch during the year 2004[7] has been increased to a total of 77 807 tons instead of the 49 435 tons declared, as this last value was clearly too low, and inconsistent with the total catches declared for BB (39 558 tons) and for the P-fleet PS (20 305 tons). A total catch of 17 944 tons has been estimated for this year 2004 for the A-Fleet PS (the average of its 2003 and 2005 catches).(cf **Table 5**)

This work will use the table of total catches declared by the P-fleet as being a correct equivalent to the total catch of this fleet. These total catches of the P-Fleet are assumed to be a component already included in the total TASKI Ghanaian catches.

This work will also incorporate the yearly amounts and estimated quarterly catch at size of the small size tunas sold as "Faux Poissons" in the Abidjan local market, as they have been estimated by the CRO sampling scheme and provided to the Ghana 2011 WG. These catches will be added to the 2 fleets as an additional catch, but without explicit fleet, and without gear. The species composition and quarterly sizes of these "faux poissons" landings during the 1996-2005 period are based on the average species composition and sizes that have been sampled & estimated in Abidjan during the 2007-2010 period (strata substitution). Two working hypothesis will be used in the data processing: (1) quantities of "faux poissons" are already included in the TASKI and (2) quantities of "faux poissons" are not included in the TASK1 and they should be added to it.

A revised TASK1 will be estimated after this data processing, keeping the present levels of total catches, but estimating a corrected species composition of these landings.

Furthermore, the yearly total catches of the 2 main fishing gears used by Ghana to target tropical tunas, BB & PS, will be kept in most calculations (but not for faux poissons), because of the apparent differences in sizes and in the species composition of tunas catches landed by each gear. These yearly total catches of each gear declared by Ghana and used to stratify the catch of the A Fleet are given in **Table 7.**

[7] The same statistical problem will also be faced for the year 2006

This data processing will not envisage the serious questions concerning the uncertainties in the levels of TASKI declared by Ghana: there are serious reasons to consider that this TASKI has been possibly underestimated during some recent years (Ann ICCAT 2011). These statistical questions are for instance quite clear concerning the P-Fleet data, a fleet that has been very poorly followed by scientists. However this TASKI question is highly complex, at a statistical level for scientists and at a political level, and it will not be included as a scope of this technical paper.

3.3 Data processing

3.3.1Geographical strata

Due to the quite low coverage of the Ghanaian log books and sample sizes during the 1996-2005 period, a 3 areas stratification (Figure 24) has been used in the proposed data processing, these 3 areas being derived from the EU FAD sampling areas shown by **Figure 23**. The yearly species composition of EU PS FAD catches in each of these 3 Ghanaian areas is shown by **Figure 25.**

- Area 1: coastal zone off Liberia, Cote d'Ivoire and Ghana: an important fishing zone for the Ghanaian tuna fleet, & an area often showing in the FAD catches by the EU PS a peculiar species composition with a higher % of YFT (but unfortunately with few samples available).
- Area 2: coastal zone off Cape Lopez, an area fished seasonally by EU PS between June and October, and also showing peculiar types of size and species composition, but at a lower degree.
- Area 3: all the other offshore fishing zones, that are assumed to be homogeneous in their species composition and sizes caught. This strong hypothesis may not 100% valid, but it appears that the size and species composition of FAD catches tend to be quite homogeneous in the offshore areas, a conclusion based on the average composition observed by 5° for the EU PS catches on FADs. However, based on the fact that the EU PS have major fishing zones north of 5°N, when the Ghanaian fleets have been very seldom fishing north of 5°N during the period (see **Figure 32**), the **species composition of EU PS FAD catches** will be calculated in the offshore areas, but **only south of 5°N.**

Table 6 provides the same basic information that will be conditioning the species composition of Ghanaian catches in the H1 and H2 hypothesis.

These species composition percentages can also be compared to the species composition sampled in Abidjan during the period 2001-2004, these catches being predominantly sampled in area 3, but also from unknown geographical position, see **Table 7.**

It should be noticed that when this SKJ percentage was similar to the levels in the EU PS FAD fishery, percentages of BET tend to be quite low, much lower than in the offshore main fishing area, but at the lower levels observed in the coastal areas of Cape Lopez & Ghana-CI.

The yearly species composition of the EU PS FAD catches in each of these 3 areas is also well summarized by the % of SKJ in the following **Figure 26**. These species percentages by area will be conditioning the species composition of the Ghanaian catches in the H1 and H2 species composition hypothesis, in proportion in the Ghanaian catches taken in these coastal areas.

This **Figure 26a** shows the lower % of SKJ observed each year in the 2 coastal areas (higher % of YFT), a fact already noted by the 2011 Ghana WG. This figure also shows that the % of SKJ in the today Ghanaian TASKI is most often well under the percentage of SKJ observed in all areas for the EU PS FAD catches. However, it appears that the coastal area off Ghana & CI has been seldom fished by the EU PS, and then that small numbers of size/species samples are available in this area. These low and variable sampling rates are a potential cause explaining the large year to year variability of the species composition of the catches estimated in the Ghana-CI area.

3.3.2 Gear stratification

Based under the conclusion of paragraph 2.9, the creation of the TASK2 for the 1996-2005 period has been done assuming a A-fleet stratified in BB & PS. Large YFT and BET have been added to the Ghanaian CAS (A & P fleets) solely in the PS samples and PS catches. It was concluded that this stratification may be interesting during the 1996-2005 period because of the visible heterogeneities in the tuna catches landed by the 2 gears, even if the tuna catches of the two gears are significantly and increasingly mixed (when this stratification should not be kept during the subsequent period 2005-2012).

3.3.3 Time strata

Quarter have been used in all data processing: assuming an homogeneous size and species composition within each quarter, but all the C/E results are provided on a 1° scale.

3.3.4 Catch & effort data used for the period 1996-2005

It could have been envisaged to extrapolate the log book data collected in Tema and in Abidjan to the total catches (TASKI) declared to ICCAT by Ghana. However, this method cannot be used because of the very low rates of log book coverage during all years, including during their best sampling period in Abidjan (2002-2004). This very poor level of the log book coverage is well summarized by figure 15 and by the quarterly fishing maps of the 2 Ghanaian fleets (**Annex 1**).

In this context, a constant quarterly fishing pattern of catches by time & area strata estimated during the 2006-2010 period has been used, using a strata substitution, to estimate the fishing strata of the various fleets. These quarterly patterns of time & area catches will be extrapolated yearly to the TASKI of each fleet (**Table 5**)

3.3.5 Free schools and FAD stratification

This data processing has not been stratified by fishing mode, but it is most often assumed that all the Ghanaian catches were caught on FAD associated schools.

3.3.6 Tunas size categories

When size categories of tuna caught are playing an important role in the EU PS data processing (estimating the species composition in each size category based on detailed log books information), the available data during this period do not allow to use this parameter in the data processing. However, it should be kept in mind that the species composition estimated from the EU PS catches that has been used to adjust the Ghanaian species composition is making of full use of these size categories.

3.3.7 Catches of large YFT and of large BET over 100 cm (about 20 kg)

Based on the 2011 WG analysis, it has been assumed that the lack/rarity of large YFT and large BET in the Ghanaian samples during the studied period was due to a sampling bias. The quantities of these large tunas have been estimated from the percentage and sizes of large YFT and of large BET estimated in the EU PS FAD catches (by time & area strata). These large tunas have been added to the Ghanaian samples in their ad hoc percentages, allowing to estimate more realistic profile of size composition of the Ghanaian catches. The yearly catch at size of these large YFT and large BET caught by EU PS on FADs have been added to the Ghanaian Tema samples in their proportion observed in the EU PS FAD samples. These proportions are given by **Table 8** (percentage of total catches in numbers).

These yearly amounts of large YFT & BET tunas have been added to the Ghanaian samples of PS and not to the BB samples, assuming that these catches of large tunas were very rare for the Ghanaian BB.

3.3.8 A three fleets stratification: P-fleet, A-fleet and S-fleet

- Catch and effort of the P-fleet (active since June 2003) during the 2003-2005 period has been assumed to be identical to the C/E quarterly pattern of its 5° catches observed during the 2009-2010 average period. These catches have been extrapolated each year to the yearly total catches declared by the P-fleet (**Table 5**). The species composition has been estimated (on the 1° scale catches) from the EU PS FAD species composition in the 3 areas, and the catch at size of these estimated catches have been estimated based on their size sampling in Abidjan during the years 2003 and 2004.

- Catch and effort of the other Ghanaian (active during the period 1996-2005) has been assumed to be identical to the average 2006-2010 C/E scheme (without 2007 data, as the log book coverage during this year is considered to be insufficient). The catches of this period have been extrapolated each year to the yearly total catches estimated for each fleet (**Table 5**) and the species composition has been estimated (on the 1° scale catches) from the EU PS FAD species composition in the 3 areas. Catch at size of these estimated catches have been estimated based on their size sampling during the years 1996-2005. This calculation has been done primarily combining PS & BB, as recommended by the 2011 WG, but also stratified by gear (BB & the 2 fleets of PS).

- The TASK2 (C/E and CAS) of the S-fleet has been processed independently by the EU T3 software (and in conjunction with the EU data & software, cf Pianet et al 2000, this S-fleet being a statistical component of the EU fleet).

3.3.9 Species composition

The new data processing has been done on 2 different hypothesis:

1) In the **1st hypothesis so called H1**: all Ghanaian catches by 1° squares were extrapolated by time and area strata assuming the yearly species composition estimated by EU scientists for the EU PS catches on FADs, using their fully stratified ad hoc TT software (Pianet et al 2000). This average species composition by area estimated during the period 1996-2005 is given at a yearly scale table 9 and shown by figure 25. All species corrections have been corrected on a quarterly and 3 areas basis, but simply assuming a constant species composition in each area; the same species composition is applied by area to both P-fleet & A-Fleet.

(2) In the **2nd hypothesis so called H2:** the species composition of the Ghanaian catches during the period 1996-2005 was estimated also using the Ghanaian multispecies sampling and now assuming (a) that the proportion of SKJ catches was identical to the % of SKJ observed in the EU PS FAD fishery (but only south of 5°N), and (2) that the proportion between YFT and BET in the Ghanaian samples was unbiased (see paragraph 2.2) and representative of the percentages of these 2 species in the Ghanaian catches. This data processing has been done on a quarterly basis (assuming each quarter a constant % of each species), and separately for BB and for PS (as the species composition of the 2 gears is often quite distinct, due to their differential selectivity between species), but without geographical stratification (assuming that the Ghanaian sampling have been done + or – in proportion to the Ghanaian catches by time & area strata).

The analysis of the proportion of BET & YFT estimated in the EU PS & Ghanaian samples during recent years has also be done in order to better evaluate its potential validity and use. The main result of this analysis is shown by **Figure 26b** where the % of BET in the YFT+BET samples are plotted by decreasing weight, for the samples taken on the 3 fleets: Ghanaian BB & PS samples and EU PS FAD samples.

This figure is based on a quite large number of samples: EU PS FAD, 5240 samples (average amount of BET 41%), Ghana BB 814 samples (average = 30% BET) and Ghana PS, 643 samples (average = 34% BET). It shows a rather striking & surprising quasi linear declining trend of BET percentages in the EU PS FAD samples, at least for the 80% of samples showing the higher rates of BET. It should also be noted that the EU & Ghanaian samples are showing quite similar patterns of levels & trends in BET %, when the Ghanaian BB & PS samples are showing some differences: BB samples often showing lower percentage of BET. These differences in BET proportions are probably due to geographical effects, BET being less abundant in coastal waters where Ghanaian fleets are very active.

3.3.10 Catches of the S-Fleet

These yearly quantities of Ghanaian/Spanish tunas landed yearly are given in **Table 5** The TASK1 & TASK2 of this peculiar segment of the Ghanaian fleet has been estimated by the EU scientists, using their TT software and when necessary doing *ad hoc* strata substitutions with the EU PS data base. For simplicity reasons in the final data processing, these minor catches and CAS estimated externally have been simply added to the Ghanaian TASK1 & TASK2 estimated by the ad hoc methods described in this paper. This simplified hypothesis could of course be changed.

3.3.11 "Faux Poissons" landed in the local market of Abidjan.

The total yearly amount of these Ghanaian tunas have been estimated by scientists, but not their exact species composition nor their sizes (sampled only since 2007). These yearly quantities of Ghanaian tunas landed yearly in the faux poisons market of Abidjan are given in **Table 5.** The new data processing proposed will assume that the species composition and sizes of each species landed in the "*Faux Poissons"* market had a typical quarterly profile of the average sizes sampled during the 2007-2010 period. These average sizes that are typical of the *faux poissons* Abidjan market are shown **Figure 27**.

For simplicity reasons, the total catches and CAS by species that have been estimated by this ad hoc strata substitution will be simply added to the basic TASK1 & TASK2 data estimated for the Ghanaian fleet, taking note that these levels of catches are quite minor ones during the period 1956-2005: an average total catch of only **1760** tons, then only 2.7 % of Ghanaian TASKI during this period.

3.3.12 Summary of the recommended data processing

The data processing that has been recommended and used during this period 1996-2005 is summarized by the flowchart **Figure 28.**

4 Results

4.1 Species composition

The new species composition of the Ghanaian fishery during the 1996-2005 period obtained by the Species Composition 1st Hypothesis and a 2 gears stratification is shown by **Table 9** and by **Figure 29**, in comparison of the previous one.

This figure shows that the species composition estimated in the 2 hypothesis H1 & H2 are very similar, but both being very different from the species composition previously assumed in the today ICCAT TASKI.

The main changes in the levels of catches by species estimated in these H1 & H2 hypothesis can be noticed as following:

- Systematic decline of YFT and showing during the period a significant average decline of 25%. Similar rates of decline are estimated in the H1 & H2 species composition hypothesis: 23 & 21 %.

- Frequent decline of BET landings but not every years, and showing during the period a significant average decline of 18% (H1) and 22 % (H2), but stable or increasing catches have been estimated during some years, for instance in 2002 & in 2004. These increases in the BET catches are due to the higher rates of BET that have been sampled on a large number of samples in Abidjan during this period (and they are probably realistic?)

- Systematic increase of SKJ landings (except in 1997?), and showing during the period an average increase of 28% .

The yearly catches by species estimated in the 2nd hypothesis of species composition H2 are given in the following **Table 10.**

It appears that when the average catches by species estimated in the 2 hypothesis H1 & H2 are very similar (**Tables 9** and **10),** the between years variability of catches by species estimated in the 2 hypothesis H1 & H2 are quite high in some years, for instance BET catches estimated by the 2 method fluctuating between 1 & 2 in 2002 and in 2004.

The results obtained in the H3 species composition are showing very similar results in the average catches of each species during the 1996-2005 period, taking note that the yearly catches estimated each year in this hypothesis are sometimes quite different for the estimated catches by species in H1 and H2. These results are given in the following table 11 and shown by **Figure 30**.

4.2 Fishing zones

The average fishing zones of the 2 Ghanaian fleets, P&A, have been estimated by 1° squares , & they are shown (by species) on figure 31 and 32. These Ghanaian fishing zones are also compared with the EU PS fishing zones on FADs (**Figure 33**).

These figures are showing the differential fishing zones observed for the two fleets, and the relative weight of each fishing zone, at least much better than the traditional CATDIS fishing maps done by the ICCAT secretariat and their artificial excessive catches in the two 5° squares off Ghana. The average quarterly fishing zones estimated now for the Ghanaian fleet during this period 1996-2005 are shown by figure 35, in comparison with the EU PS FAD fishing zones during the same period (**Figure 36**).

The average fishing zones that have been estimated for the Ghanaian fleet during the period 1996-2005 (based on the 2006-2010 fishing zones) can be compared with the average geographical locations of catches that have been recorded in the too rare log books by 1° squares. This result is shown by **Figure 34.**

The comparison of **Figure 32** y **34** would indicate that the fishing zones that have been estimated by strata substitution with recent years are quite consistent with the log book data of the 1996-2005 period. However, it should be noted that the log book catches 1996-2005 in the area of Cape Lopez are much lower than the catches estimated by strata substitution in this area, and that they may be overestimated.

It should be noted that this fishing pattern of Ghanaian vessels is showing fishing patterns that are quite different from the EU PS fishing patterns, for instance showing:

- Much more important catches in the coastal areas off Ghana and Ivory Coast

- Very low seasonality of most of its fishing zones (keeping in mind that this conclusion is totally driven from the 2006-2010 log books used to estimate the 1996-2005 fishing patterns).

- For instance, noting the fishing activity all year round off Cap Lopez, when on the opposite the EU PS fishery is always seasonal, see the following maps, **Figure 36.**

- The very low catches of the Ghanaian fleet at latitude north of 5° N in the central western Atlantic (the opposite for the UE PS FAD fishery).

4.3 Catch at size by species.

The average catch at size of the 3 species estimated in the H1 hypothesis of species composition are shown (in weight, by 2 cm class) as histograms by **Figure 37**. These figures are based on the new species composition, and they incorporate the Faux Poissons landings and the amount of additional large YFT and BET that have been estimated from the EU PS FAD catches and added to Ghanaian BB and PS in proportion of their yearly catches by gear.

These three figures are showing:

(1) An increase in the new CAS estimated for SKJ due to increased SKJ catches, and also larger numbers of very small SKJ due to the catches of *"faux poissons"*.

(2) Significant weight of large YFT and large BET are now caught by the Ghanaian fleet.

(3) A marked decline in the numbers of small YFT and of small BET caught by the Ghanaian fleet, due to the decline of total catches of the 2 species and to the increased catches of large tunas.

The CAS caught by each gear BB & PS are also interesting to compare, for instance the CAS of YFT estimated in the H1 hypothesis, see **Figure 38.**

In this estimated CAS, a small percentage of YFT were caught by PS at size over 1 m during the average period 1996-2005 (only 4.2%), but these sizes caught correspond to a large percentage: 39% in weight. However, it should be kept in mind that these large size YFT have been mainly estimated from the EU FAD samples. On the opposite, catch at size of BB & PS estimated for BET and SKJ are very similar for small fishes.

The average CAS by species during the 1996-2005 period estimated in the H3 hypothesis are shown in weight, for the 3 species by **Figure 39**, in comparison with CAS previously assumed by SCRS.

These average CAS by species estimated in the H1, H2 & H3 species composition hypothesis are very similar,, being nearly identical at the level of their 10 years average (simply because total catches by species are very similar, and because the same samples are extrapolated to these same average levels of catches).

4.4 Average weight of Ghanaian catches

The new CAS presently estimated allows to estimate the yearly average weights caught yearly by BB & by PS (including large YFT & BET added from EU PS and *faux poissons* CAS). This basic result is given by **Table 12.**

4.5 PS & BB apparent heterogeneity

The proposed data processing stratified between BB & PS allows to compare the CAS & species composition estimated for each of the 2 gears, this results being of peculiar interest for the H2 hypothesis. In the H1 hypothesis, the species composition of the 2 gears is identical by time & area strata, both gears being conditioned by the EU PS sampling. As a result, this PS/BB stratification has no visible consequences in the H1 hypothesis.

However, in the H2 hypothesis where the species composition of each gear is widely conditioned by their sampling, some differences are introduced by the hypothesis H2 in the species composition of each gear. This is for instance the case for the amount of BET caught by BB and by PS that are showing each year distinct changes of their species composition in H1 & H2, see **Figure 40**.

The average species composition of BB & PS appears to be quite distinct during the period, less SKJ and more YFT caught by BB, this estimated difference being similar in the 2 working hypothesis H1 & H2, see **Table 13**.

4.6 YEAR 1996: TASKI &TASK2 estimated by the 2011 WG & in 2013

As this year has been estimated by the 2 ICCAT WGs in 2011 and in 2013, there is a potential choice now to use one or the other series for future stock assessment of tropical tunas. The species composition of Ghanaian catches during this year 1996, estimated by the 2011 WG and now are shown by **Table 13.**

It can be noticed that the new data processing has been keeping similar level of SKJ catches (+7%), but producing more significant changes of BET estimated catches (+21%) and of YFT catches (-25%).

Furthermore, the fishing zones estimated in these 2 series appear to be quite distinct: the 1996 fishing zones estimated in 2011 being substituted with previous years data (average period 1982-1986, then a quite historical period), when the present fishing zones are estimated based on the 2006-2010 log books (**Figures 41a & 41b**).

Fishing zones presently estimated are quite similar, but larger than in 2011, for instance reaching now 25°W and only 10°W before). It is impossible, based on statistical evidence, to firmly conclude what are the best & more realistic statistical series for this “frontier year” 1996. However, based on the 3 following facts that:

(1) the 2011 data processing was based on strata substitution with a remote historical period 1982-1988;

(2) that the species composition is now much more realistic than in 2011; and

(3) that the 1996 fishery that was already active on FADs (Bannerman & Bard 2002)developed on FADs should preferably be compared to the today fishery, then it should be recommended to use the 1996 TASKI & TASK2 data set estimated now, instead of the previously estimated 2011 series.

4.7 Fishing efforts in the proposed C/E series

The proposed statistical C/E series contain fishing efforts, but it should be kept in mind that these fishing efforts have been obtained by strata substitution from the recent period. As a consequence, these fishing efforts have very little or no scientific value and they should never be used in any stock assessment work (the same comment being also valid for the previous two periods of Ghanaian statistics that were also based on strata substitution with other fleets (1st period) or other period (2nd period).

4.8 A-Fleet catch by species estimated in the 2 gears & in the 1 gear stratification

An alternate data processing of the A-Fleet data done without taking into account the fishing gear has been done, allowing to estimate total catches and CAS by species, and to compare these catches with the previously estimated catches by species and gear (keeping in mind that SKJ catches that are driven by EU PS FAD catches are unchanged by hypothesis). These total catches by species are given on **Table 15** and **Figure 42** is showing the total catches of BET that have been estimated in these 1 & 2 gears stratifications.

This table and figure are showing that the species composition of the fleet A catches are very similar in the 2 methods, the worse difference between the 2 results being observed in 2004 with an increase of 950 t. (about 10%) of the BET catches in the 1 gear hypothesis.

The levels of CAS are changed in proportion of these changes in total catches of YFT & BET, but also at a minor degree.

These comparative results would tend to the conclusion that the combined gears stratification could also be used in the data processing, as it was recommended by the 2011 WG, and without introducing major changes in the results. However, it should be kept in mind that the differential selectivities between PS & BB, and the potential catches of large YFT in FAD and in free schools by purse seiners, an important factor in the data analysis, stock assessment and management, would be lost from the Ghanaian statistics if this combined gear method is used in the Ghanaian data processing.

4.9 Catches by species: before & after correction

It is also interesting to compare the species composition of Ghanaian catches before its correction of species composition and after the present data processing. This comparison is summarized by **Figure 43** showing the percentages of SKJ and of BET in the original Ghanaian log books and after the H2 hypothesis data processing.

This figure shows a paradoxical fact that the Ghanaian log books contains proportions of SKJ that are very similar to the amount of SKJ estimated in the H2 hypothesis (base on EU PS FAD sampling): only showing an average decrease from 62.7% to 61.8% (when the TASKI level presently estimated by ICCAT secretariat was much lower at only 50.6%). The H3 species composition hypothesis was based on this result that the amount of SKJ estimated by Ghanaian in the log books are very similar to the amounts of SKJ estimated on FAD from the EU PS sampling, and that subsequently these amounts of SKJ could be well used in the data processing of the Ghanaian TASK2.

On the opposite, the percentages of BET are widely underestimated in the log books (4.7%) and they have been multiplied by a factor of 3 to reach their presently estimated average level of 13.8% of total catches (also producing equivalent declines of the YFT catches).

5 Data processing of the 2006-2012 TASK2: first results & prospects

5.1 General considerations

Major improvement in the 2006-2012 Ghanaian data should be noticed:

1) Better data: more size samples with good species identification (unfortunately still biased in terms of species composition until July 2012) & much more log books, reaching a 100% coverage. All species composition of the 2006-July 2012 period should be corrected, one way or another.
2) Including a quite good statistics on the PANOFI fleet.
3) Better potential validation of the all basic data for all years entered under the AVDTH framework and using its validation routines (AKADO & other)
4) Much better sampling of "*Faux poissons*" in Abidjan: now with a good species and size composition during this period!
5) Useful validation of scientific data by the data given to ICCAT (via ISSF) by the PIONEER cannery. This commercial data set that is covering large quantities of processed tunas (close to 40.000t yearly) is very powerful to allow independent data cross validations of the landing data in Tema, as it contains the landed total catches of several vessels (especially the PIONEER PS), including some P Fleet catches, and with a quite good size and species composition of these landings: at least for catches of SKJ and large YFT that are very well identified in these data.
6) Good sampling of large tunas starting in 2009, keeping in mind that large YFT and BET should be added to the samples of previous years.

The data processing of this period will be done using widely different methods: as the log book and size sampling coverage are quite good for the A-Fleet during this period, at least during some years, this data processing will simply be done based on the extrapolation of log book and sampling data (with only few small scale strata substitutions routinely handled by the TTGhana software), However, the A-Fleet during the year 2007 will also need to be estimated by strata substitution with neighbouring years, at least to a great extent, because of the weakness of its log book data available in 2007 (an average coverage of only 16%).

On the opposite, the data processing of the P-fleet will require during the 2006-2009 period large scale strata substitutions, similar to the one used for the 2003-2005 period. Furthermore, the analysis of the heterogeneity between sizes and species landed during this recent period 2006-2012 tend to show an homogeneity of BB & PS landings (same percentages of large YFT & large BET sampled on the BB & PS landing in 2011, probably the result of frequent exchanges of catches between the 2 gears), and consequently, the data processing should solely be conducted during this period without stratification between PS and BB. The H3 hypothesis would appear to be the best one to estimate and to correct the species composition during this period. Total catches in 2006 should also be corrected, because the total of BB & of P fleet catches is larger than the TASKI declared by Ghana. These 2006 catches have been tentatively increased to a level of 71,600 t (instead of the today 51,300 t), assuming an average level of the A-fleet PS catches.

5.2 Experimental tentative data processing of the 2006-2010 period

A tentative 1st data processing of this period 2006-2010 has been done also in the H3 hypothesis of species composition and combining all the PS & BB data in a combined gear: estimating the percentages of SKJ from the Ghanaian log books, and later estimating the percentages of YFT and BET from the multispecies sampling of Ghanaian landings. It has been assumed in this data processing that large YFT and large BET have been well sampled since 2006 (the alternate hypothesis and the addition of some large tunas from the EU PS FAD fishery should also be envisaged in future data processing).

5.3 Results

The corrected species composition obtained by this preliminary data processing is given in the following **Table 16.** These preliminary analysis and their first results are solely indicative. The rates of SKJ catches obtained after this data processing appear to be slightly higher than during previous years

5.4 Pending questions in the data processing

However this data processing will also be facing **new and/or increasing statistical questions** during this recent period 2006-2012:

1) Increasing uncertainties on the Ghanaian TASK1 due to possible underestimated catches, as shown by log book entries of the A Fleet that are sometimes higher than its TASKI. Also Kebe 2011 report suggesting this potential underestimated TASKI.
2) Bias in the samples of large YFT and large BET in Tema? There is a need to compare the detailed data of individual landings of these large tunas, estimated from scientific sampling and from the Pioneer cannery (as these large tunas are perfectly well identified by the cannery).
3) Serious questions on the increasing PANOFI fleet and of its activities: a good log book coverage in 2010, but no coverage or a very low coverage during the years 2006-2008. This should lead to an absolute re-estimation of the TASK2 of this fleet using strata substitution with recent years, & not extrapolating log books. Many pending statistical questions will remain on this major & efficient fleet, due to its at sea transhipments during the period under study and the lack of control of its log books and landings by Ghanaian scientists.
4) A change in the Ghanaian catch pattern: more free schools caught during recent years, for instance by the MW BRANDS PS fleet? A need to explore recent Ghanaian log books, searching if these typical free schools sets are now occurring? A need to create soon a free schools component in the data processing ?
5) A need to do, starting in 2011/2012, a full data processing of the BELIZE flags PS in the Ghanaian data processing and data base? Similar to the EU NEI PS.

6) Serious questions remains on some components of the species composition in the PIONEER cannery: quantities of BET estimated by the cannery appear to be widely underestimated and the BET quantities should necessarily be estimated based on scientific multispecies sampling.

7) C/E data for the S-Fleet have been collected & well processed by EU scientists, but since 2006 it would appear that this data set has not yet been submitted to the ICCAT secretariat due to administrative constraints in the circulation of TASK2 data. This 2006-2009 data set of the S-Fleet should be recovered and incorporated in the future Ghanaian TASK2

6 Conclusion

The presently estimated Ghanaian TASK1 & TASK2 cannot be considered, & by far, as being an ideal data set based on good log books and large unbiased samples covering the various Ghanaian fleets. This data processing has no choice, but to rely mainly on a wide range of hypothesis and strata substitutions. Its basic goal was simply to provide more ***realistic working files of Catch & effort and Catch at size*** that can be used in future SCRS stock assessment works and other analysis on tropical tunas: based at least on a realistic species composition, realistic time and area fishing zones and realistic catch at size off the 3 species.

This more realistic species composition is also of great importance for the Ghanaian TASK1 series. These proposed new series of TASK1 & 2 are probably much better than the Ghanaian TASK1 & 2 available today to ICCAT scientists, as the ICCAT series available until 2012 were clearly widely unrealistic (1) in their species composition (not enough SKJ & too much BET & YFT!), (2) in their fishing zones artificially concentrated in the 5° square off Ghana, and (3) their catch at size by species (with too many small YFT & BET, and not enough big fishes). All these series of proposed TASK1 & 2 are the ones that are considered to be the best ones today, based on the data and data processing hypothesis that have been considered as being the most convenient ones. A positive factor in this work was that all these methods and hypothesis have been providing TASK1 and TASK2 series that are very similar between them, and always very different from the non corrected Ghanaian data presently available.

Some of the rules proposed for this 1996-2005 period should also be used in the planned data processing of the 2006-2012 period, keeping in mind that some of the same sampling bias have been in place until 2012, but with the positive factors that the Ghanaian log books and sampling coverage and their data validation, have been widely improved since 2006, probably allowing to do a full data processing & with few strata substitutions, at least for the A fleet.

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Table 1. Average percentages of large YFT and of large BET >1 m observed, in numbers, in the random samples of the Ghanaian fleet landing in Abidjan in 2003 & 2004 (16300 tunas measured)

Gear	Year	YFT	BET
BB	2003	2,64	2,31
BB	2004	0,97	0,16
	Average	1,81	1,23
PS	2003	8,27	1,95
PS	2004	6,67	3,70
	Average	7,47	2,83

Table 2. Yearly numbers of tunas sampled on the Ghanaian landings, by gear and by species.

Gear	Species	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
PS	YFT	982	4 538	5 602	2 804	2 792	3 425	7 176	10 030	5 623	1 662	44 634
PS	SKJ	2 320	7 986	17 998	5 214	4 224	3 836	13 011	40 156	34 238	3 266	132 248
PS	BET	692	2 764	3 442	2 076	1 098	770	2 692	6 405	9 645	1 070	30 654
BB	YFT	13 214	15 104	10 600	8 458	5 316	6 684	16 197	11 334	5 648	4 944	97 498
BB	SKJ	30 596	37 860	20 996	15 810	9 594	15 320	50 868	28 812	16 279	10 188	236 323
BB	BET	6 156	9 868	8 370	4 588	828	3 494	6 168	6 161	5 212	2 798	53 643
All	YFT	14 196	19 642	16 202	11 262	8 108	10 109	23 373	21 364	11 271	6 606	142 132
All	SKJ	32 916	45 846	38 994	21 024	13 818	19 156	63 879	68 968	50 516	13 454	368 571
All	BET	6 848	12 632	11 812	6 664	1 926	4 264	8 859	12 565	14 857	3 868	84 296

Table 3. Yearly catches and average % of free schools catches of the S-Fleet purse seiners during the studied period.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Catches	2027	3142	3756	2160	2927	0	510	3085	3853	2608
% Free schools	44	18	7	56	70		8	39	25	32

Table 4. Number of tuna sampled by gear during each quarter of the 1996-2005 period (T3TABCOGHANA9605.XLS)

Year	Quarter	PS	BB	Total
1996	1	484	7 818	8 302
1996	2	330	4 828	5 158
1996	3	557	4 246	4 803
1996	4	626	8 091	8 717
1997	1	920	6 823	7 743
1997	2	1 188	7 783	8 971
1997	3	2 886	7 145	10 031
1997	4	2 650	9 665	12 315
1998	1	3 975	6 668	10 643
1998	2	4 547	4 739	9 286
1998	3	2 341	4 093	6 434
1998	4	2 658	4 483	7 141
1999	1	2 041	6 683	8 724
1999	1	2 041	6 683	8 724
1999	2	1 710	4 830	6 540
1999	2	1 710	4 830	6 540
1999	3	1 189	1 803	2 992
1999	3	1 189	1 803	2 992
1999	4	107	1 112	1 219
1999	4	107	1 112	1 219
2000	1	1 098	1 882	2 980
2000	2	834	2 050	2 884
2000	3	471	1 183	1 654
2000	4	1 654	2 754	4 408
2001	1	939	1 701	2 640
2001	2	567	2 535	3 102
2001	3	1 211	4 322	5 533
2001	4	1 298	4 192	5 490
2002	**1**	**3 915**	**16 672**	**20 587**
2002	**2**	**3 513**	**13 446**	**16 959**
2002	**3**	**3 704**	**4 748**	**8 452**
2002	**4**	**307**	**1 751**	**2 058**
2003	1	3 755	4 177	7 932
2003	2	6 022	8 811	14 833
2003	3	8 451	3 720	12 171
2003	4	10 068	6 445	16 513
2004	**1**	**428**	**1 556**	**1 984**
2004	**2**	**3 390**	**7 786**	**11 176**
2004	**3**	**17 357**	**1 934**	**19 291**
2004	**4**	**3 578**	**2 294**	**5 872**
2005	1	1 000	1 996	2 996
2005	2	599	2 388	2 987
2005	3	600	2 389	2 989
2005	4	800	2 192	2 992

Table 5. Yearly total catches of the various components of the Ghanaian fisheries identified and used in the present data processing

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
BB	28 551	36 941	43 245	47 026	32 105	56 241	25 848	27 602	39 558	35 766
PS PANOFI	0	0	0	0	0	0	0	7 175	20 305	26 258
PS Non PANOFI	8 576	14 660	21 962	36 220	20 439	31 833	35 428	21 833	**17 944**	14 055
total TASKI	37 127	51 601	65 207	83 246	52 544	88 074	61 276	56 610	77 807	76 079
"Faux poissons" tunas	884	1 540	236	684	2 126	182	0	2 948	3 237	5 759
Spanish/Ghanian PS	0	0	0	0	2 027	3 142	3 756	2 160	2 927	0

Table 6. Average yearly species composition of FAD catches in the EU PS FAD fishery, in the 3 areas presently used

Area	Species	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average
Ghana-CI	YFT	25,8	59,1	20,4	43,8	41,7	48,2	23,9	37,9	33,6	13,9	**34,8**
	SKJ	59,4	34,6	66,9	51,4	54,3	49,0	63,7	56,8	59,0	77,1	**57,2**
	BET	14,8	6,4	12,7	4,8	4,0	2,8	12,5	5,3	7,5	9,1	**8,0**
CapeLopez	YFT	37,1	41,9	40,3	33,6	34,5	34,3	38,9	27,8	26,9	22,2	**33,7**
	SKJ	45,9	44,6	48,4	58,8	57,5	56,0	54,3	63,6	66,2	71,1	**56,6**
	BET	17,0	13,5	11,3	7,7	8,1	9,7	6,7	8,6	6,9	6,8	**9,6**
Offshore	YFT	13,7	14,0	17,7	12,1	14,4	13,0	12,9	13,9	13,1	14,7	**13,9**
	SKJ	66,1	65,4	60,9	65,1	66,9	63,2	64,5	65,1	73,5	73,2	**66,4**
	BET	20,2	20,6	21,4	22,8	18,7	23,8	22,6	21,0	13,5	12,1	**19,7**
Total	YFT	26,1	38,7	26,0	29,9	30,3	32,1	26,0	26,7	24,7	16,8	**27,7**
	SKJ	56,7	47,2	58,1	57,8	59,6	57,5	60,4	62,1	66,0	73,7	**59,9**
	BET	17,2	14,1	15,9	12,3	10,1	10,4	13,6	11,1	9,3	9,4	**12,3**

Table 7. Average yearly species composition of Ghanaian catches sampled in Abidjan during the 2001-2004 period (expressed in % caught by species).

	2001	2002	2003	2004	Average
YFT	39	54	28	10	33
SKJ	55	43	65	73	59
BET	6	3	7	17	8

Table 8. Percent in numbers of large YFT and large BET >1m. in the EU PS FAD catch at size (in per thousands of the total CAS on FADs).

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
% Big YF	**14,0**	**10,3**	**5,8**	**3,9**	**4,3**	**3,4**	**5,7**	**3,4**	**5,0**	**3,5**	**5,8**	**2,7**	**4,0**	**3,1**	**3,0**
% Big BE	**1,8**	**1,5**	**0,9**	**2,3**	**0,7**	**1,9**	**0,9**	**1,6**	**1,2**	**1,0**	**1,2**	**1,3**	**0,9**	**1,0**	**1,0**

Table 9. Species composition of the Ghanaian fishery: before and proposed, based on the species composition of EU PS on FADs (H1).

year	YFT	SKJ	BET	Total	*%SKJ*	YFT	SKJ	BET	Total	*%SKJ*
1996	11 720	19 602	5 805	37 127	*52,8*	7904	22635	6589	37128	*61,0*
1997	15 437	26 336	9 828	51 601	*51,0*	17664	26498	7438	51601	*51,4*
1998	17 656	34 182	13 369	65 207	*52,4*	13992	40125	11090	65207	*61,5*
1999	25 268	40 215	17 763	83 246	*48,3*	21139	49691	12417	83246	*59,7*
2000	17 662	28 973	5 909	52 544	*55,1*	13826	32266	6452	52544	*61,4*
2001	33 545	42 488	12 041	88 074	*48,2*	24802	50404	12867	88073	*57,2*
2002	23 673	30 498	7 105	61 276	*49,8*	11843	38642	10787	61272	*63,1*
2003	18 457	24 596	13 557	56 610	*43,4*	12912	35226	8473	56610	*62,2*
2004	15 053	25 726	14 900	55 679	*46,2*	15834	53310	8663	77807	*68,5*
2005	17 492	44 671	13 916	76 079	*58,7*	11559	56257	8263	76079	*73,9*
Average	***19 596***	***31 729***	***11 419***	***62 744***	**50,6**	***15 148***	***40 505***	***9 304***	***64 957***	**62,0**

Table 10. Species composition of the Ghanaian fishery: before and proposed, based on a species composition H2 combining EU PS on FADs and Tema multispecies samples.

	YFT	SKJ	BET	Total
1996	9 236	22 638	5 264	37 138
1997	14 921	26 502	10 189	51 612
1998	14 094	40 127	10 995	65 216
1999	22 672	49 694	10 890	83 255
2000	14 661	32 270	5 623	52 553
2001	26 328	50 407	11 348	88 083
2002	17 387	38 645	5 250	61 282
2003	13 585	35 232	7 810	56 628
2004	11 048	53 316	13 460	77 824
2005	11 750	56 262	8 083	76 095
Average	**15 568**	**40 509**	**8 891**	**64 969**

Table 11. Species composition of the Ghanaian fishery: before and proposed, based on a species composition H3, based on Ghanaian log books (SKJ) and multispecies Ghanaian samples (BET & YFT).

Year	YFT	SKJ	BET	Total
1996	8 182	24 205	4 751	37 138
1997	15 080	26 364	10 165	51 609
1998	13 222	41 840	10 155	65 216
1999	20 815	52 024	10 416	83 255
2000	12 304	34 980	5 269	52 553
2001	23 392	55 475	9 214	88 081
2002	18 100	37 570	5 611	61 280
2003	15 002	32 977	8 646	56 624
2004	14 044	46 030	17 744	77 817
2005	13 019	54 209	8 860	76 089
Average	**15 316**	**40 567**	**9 083**	**64 966**

Table 12. Yearly average weights (kg) of YFT, SKJ and BET caught yearly by Ghanaian vessels in the H1 species composition.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
YFT	**7,1**	**6,2**	**5,2**	**3,6**	**3,8**	**3,7**	**4,3**	**3,2**	**3,6**	**3,7**
SKJ	**2,1**	**2,3**	**2,2**	**2,0**	**2,2**	**2,0**	**2,3**	**2,0**	**1,9**	**2,2**
BET	**3,1**	**3,6**	**3,5**	**3,6**	**3,1**	**3,5**	**3,6**	**3,7**	**3,2**	**3,1**

Table 13. Average species composition of BB & PS estimated in H1 & H2 (in %).

	YFT	SKJ	BET
PS H1	19,6	64,6	15,9
PS H2	22,2	64,6	13,2
BB H1	26,1	60,7	13,2
BB H2	25,3	60,7	14,0

Table 14. Ghanaian catch by species of the fishing year 1996 estimated in 2011 and now H3.

	YFT	SKJ	BET	Total
1996 WG 2011	10 506	21 184	5 438	37 128
1996 H3	7 908	22 638	6 592	37 137
Change %	-24,7	6,9	21,2	

Table 15. Yearly total catches by species estimated for the A fleet based on a 1 or a 2 gears stratification.

Year	YFT	SKJ	BET	Total	**YFT**	**SKJ**	**BET**	**Total**
1996	9 423	22 637	5 074	37 135	**9 236**	**22 638**	**5 264**	**37 138**
1997	15 202	26 500	9 905	51 608	**14 921**	**26 502**	**10 189**	**51 612**
1998	14 352	40 127	10 734	65 214	**14 094**	**40 127**	**10 995**	**65 216**
1999	22 784	49 692	10 775	83 252	**22 672**	**49 694**	**10 890**	**83 255**
2000	14 622	32 268	5 660	52 550	**14 661**	**32 270**	**5 623**	**52 553**
2001	25 957	50 405	11 716	88 079	**26 328**	**50 407**	**11 348**	**88 083**
2002	17 854	38 644	4 780	61 278	**17 387**	**38 645**	**5 250**	**61 282**
2003	11 832	30 586	7 022	49 440	**11 949**	**30 588**	**6 909**	**49 445**
2004	7 911	38 543	11 053	57 507	**8 865**	**38 544**	**10 102**	**57 511**
2005	7 703	36 993	5 131	49 827	**7 669**	**36 994**	**5 168**	**49 831**

Table 16. Total catches by species estimated for the 2006-2010 period (faux thons being added to TASKI).

	YFT	*SKJ*	*BET*	*Total*	*%SKJ*	*% SKJ TASKI*
2006	16 747	46 592	12 893	76 232	61,1	58,9
2007	11 435	48 873	8 606	68 913	70,9	54,6
2008	14 986	44 818	7 456	67 261	66,6	61,4
2009	13 405	52 133	6 367	71 905	72,5	55,5
2010	22 336	60 623	7 907	90 867	66,7	73,6
Average	***15 782***	***50 608***	***8 646***	***75 035***	***67,6***	***60,8***

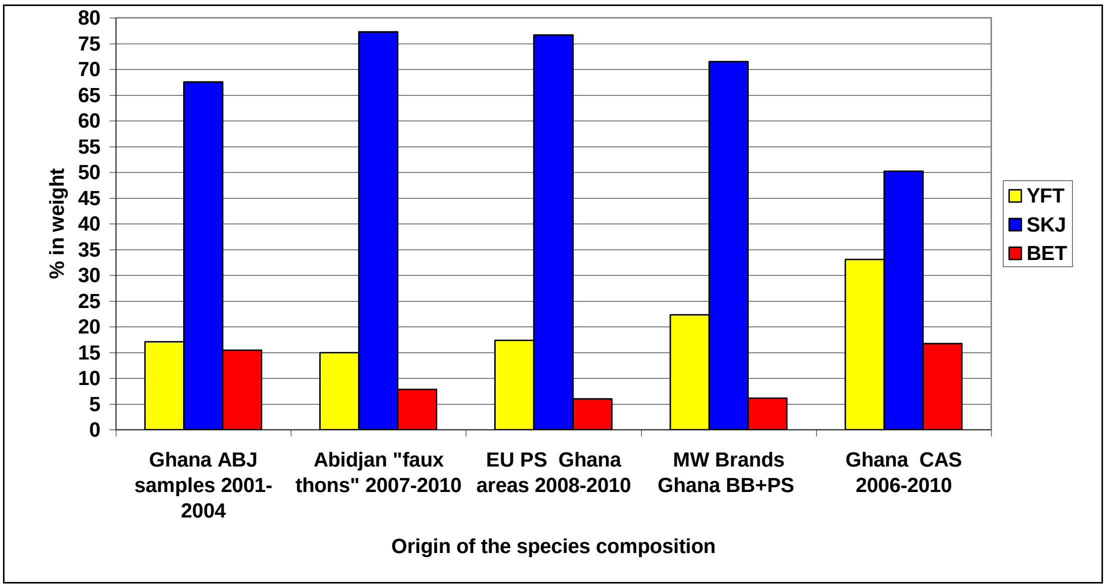


Figure 1. Comparative overview of the average species composition of various segment of fleets or of sampling schemes

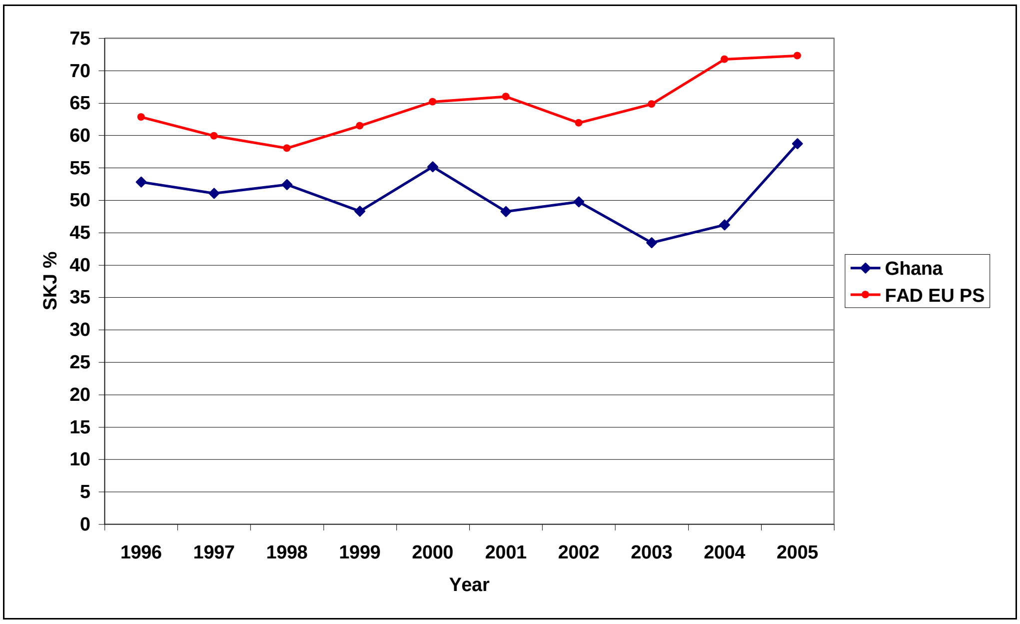


Figure 2. Percentage of SKJ in the sampled Ghanaian landings and in the EU PS FAD total catches

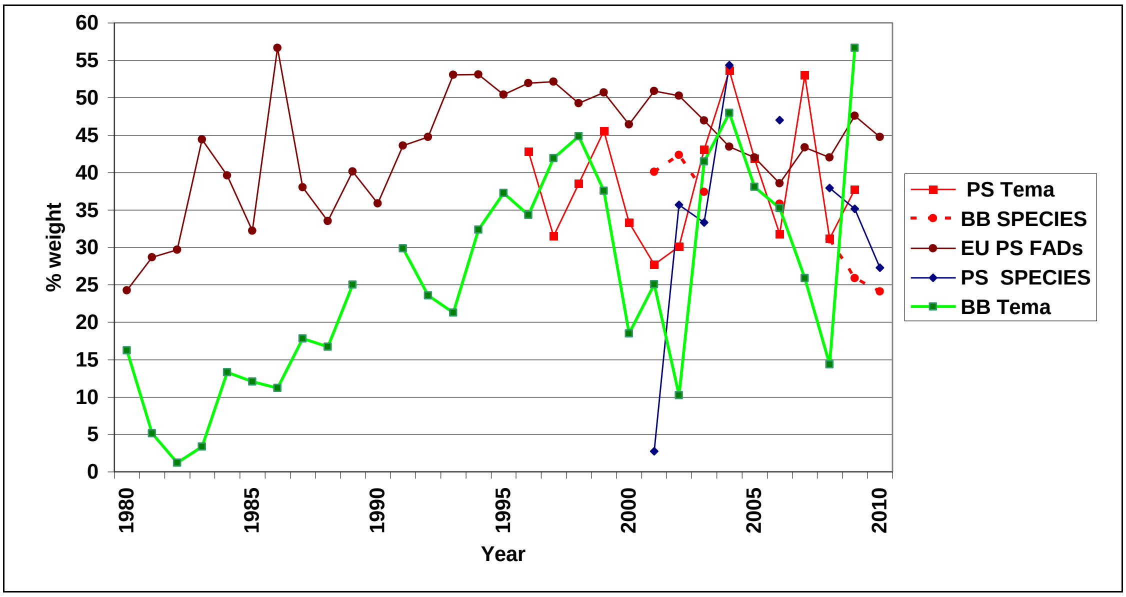


Figure 3. Yearly percentage of BET in the sampled catches of various Ghanaian fleets and from various data processing sources.

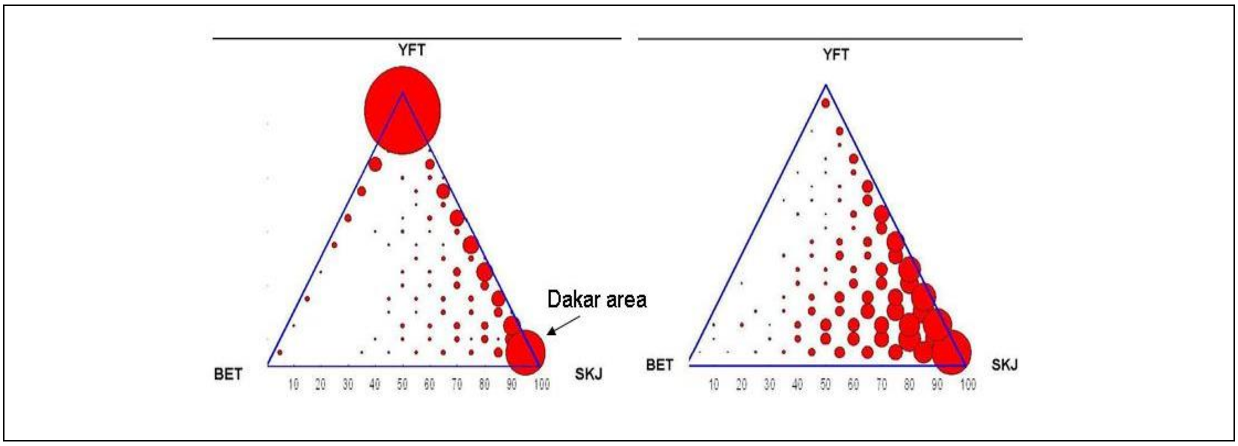
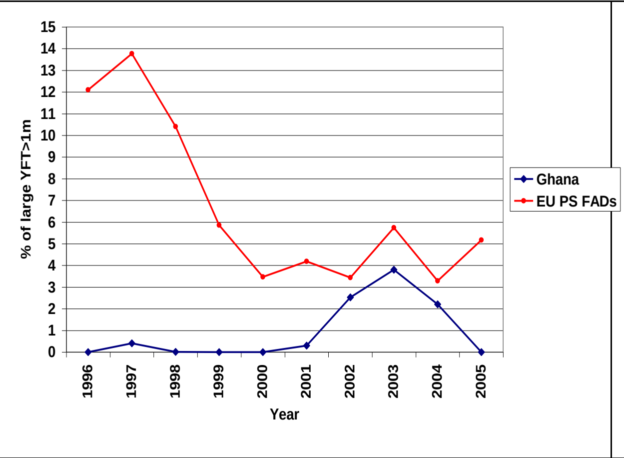


Figure 4. Observed species composition of the free (left) and FAD (right) schools set in the Atlantic on EU PS (shown by Definetti plots. the area of each circle is proportional to the frequency of the observed species composition and to the % (in weight) of each species in all sampled sets).



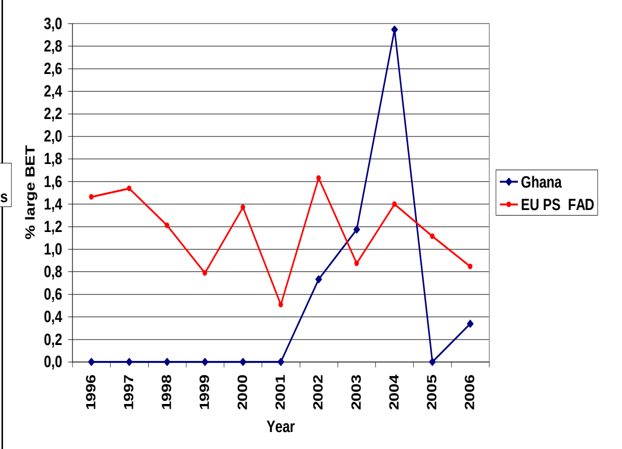


Figure 5. Yearly percentages of large YFT over 1 meter in the nominal Ghanaian samples and in the extrapolated EU PS FAD samples (NB: 2002-2004 samples dominated by Abidjan CRO sampling).

Figure 6. Yearly percentages of large BET over 1 meter in the nominal Ghanaian samples and in the extrapolated EU PS FAD samples (2002-2004 samples dominated by Abidjan CRO sampling)

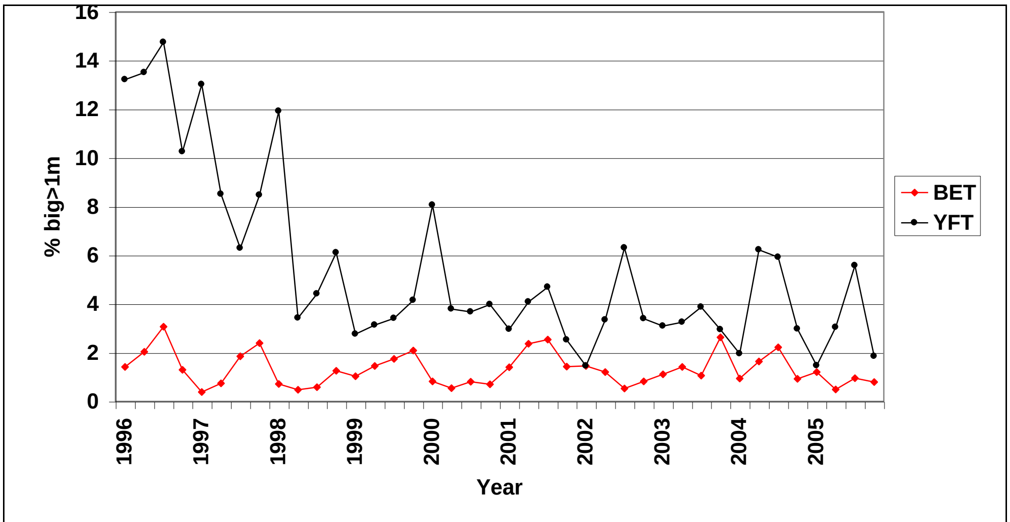
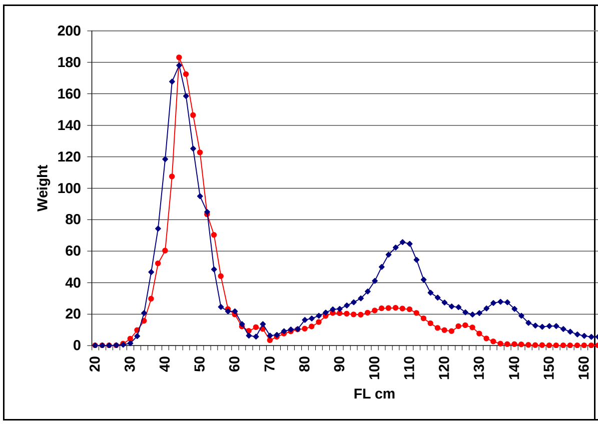


Figure 7. Quarterly percentages of large YFT & BET over 1 m caught by the EU PS on FADs during the studied period.



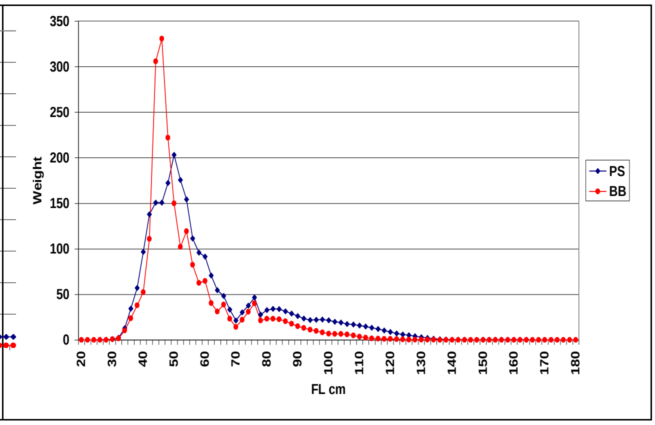
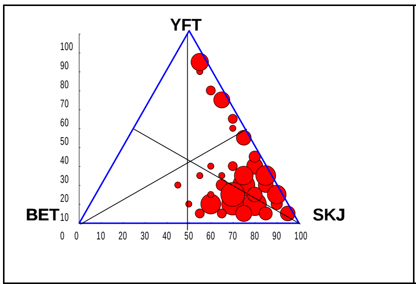
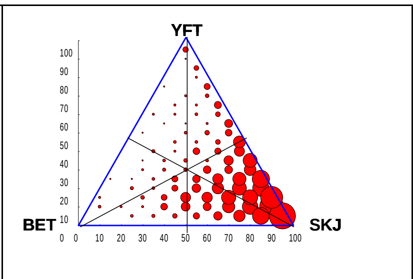


Figure 8. Ghanaian YFT samples (weight) made on PS & on BB in Abidjan in 2003-2004

Figure 9. Ghanaian BET samples (weight) made on PS & on BB in Abidjan in 2003-2004





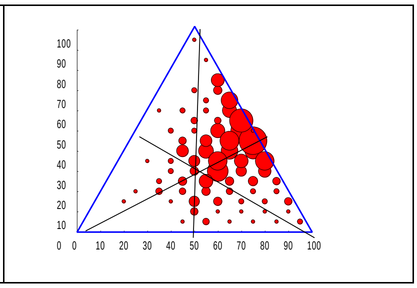
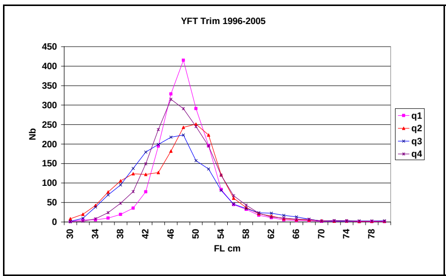
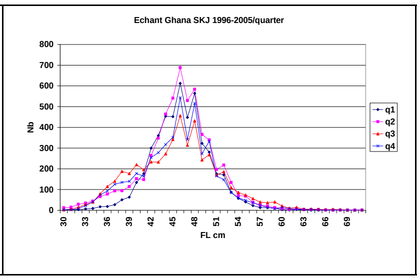


Figure 10a. Species composition of Ghanaian ABJ samples 2003-2004.

Figure 10b. Species composition of EU FAD PS samples 2006-2010.

Figure 10c. Species composition of Tema samples 2006-2010.





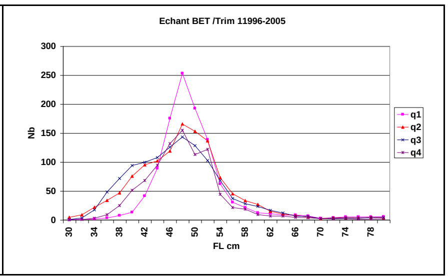


Figure 11a. Average quarterly size distribution of the sampled YFT caught by Ghanaian vessels during the 1996-2005 period.

Figure 11b. Average quarterly size distribution of the sampled SKJ caught by Ghanaian vessels during the 1996-2005 period.

Figure 11c. Average quarterly size distribution of the sampled BET caught by Ghanaian vessels during the 1996-2005 period

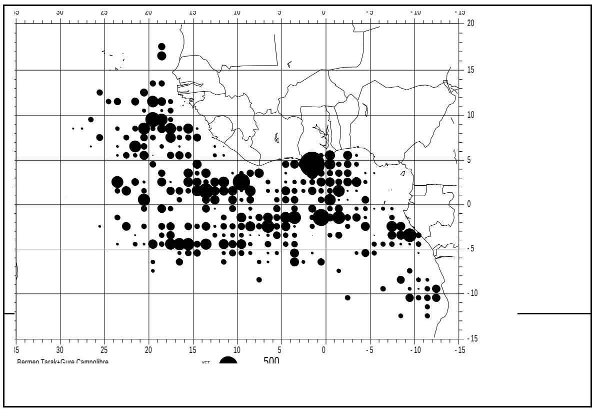


Figure 12. Average fishing zones of the S-fleet PS during the 1996-2005 period.

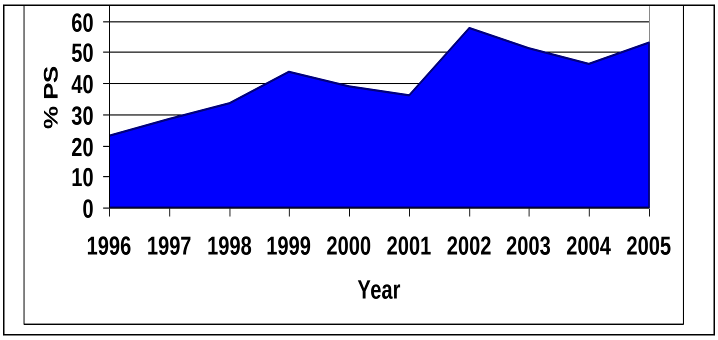


Figure 13. Yearly percentage of PS catches in the total Ghanaian landing (2004 PS catches corrected).

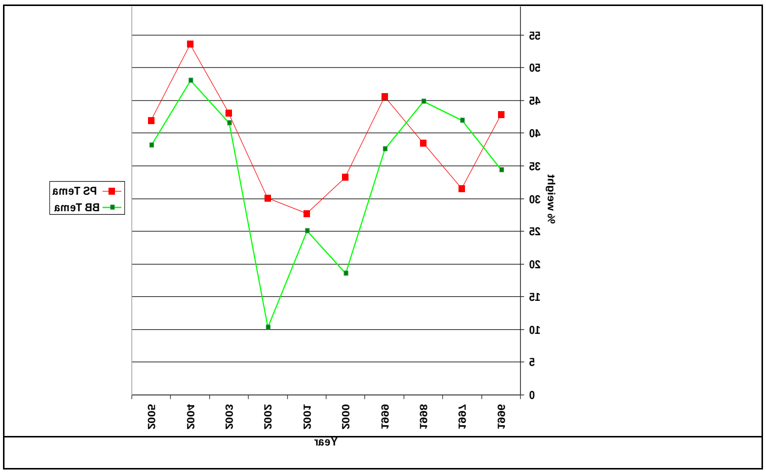
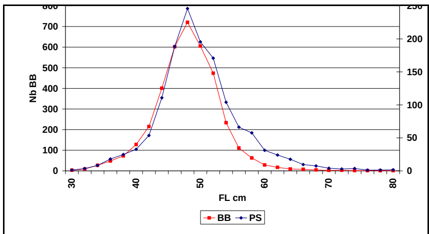
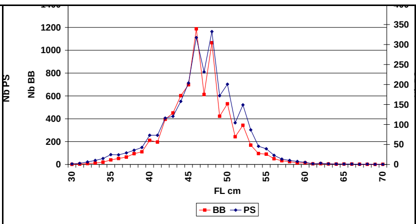


Figure 14a. Percentage of BET in the YFT+BET catches of BB & of PS sampled in Tema.





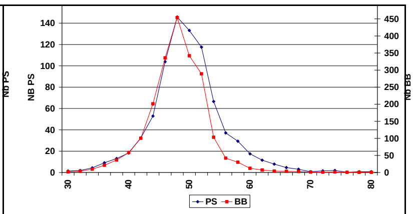


Figure 15a. average sizes of the small YFT sampled on Ghanaian BB and PS landings (1996-2005).

Figure 15b. idem SKJ.

Figure 15c. idem BET.

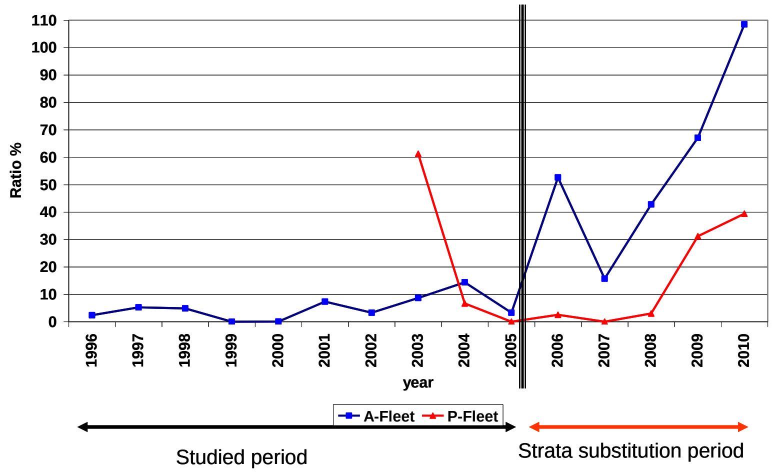


Figure 16. Yearly percentage of catches covered by log books for the P-Fleet and for the A-fleet during the 1996-2010 period.

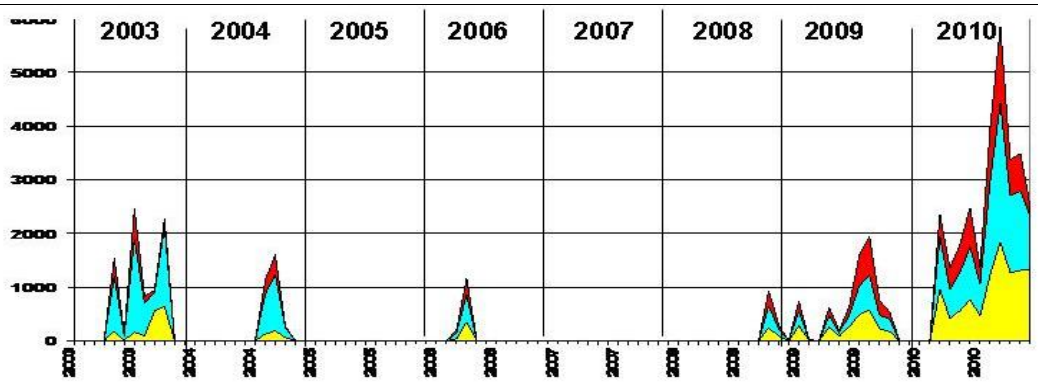


Figure 17. Monthly amount of tunas covered by the P-Fleet log books during the 2003-2010 period.

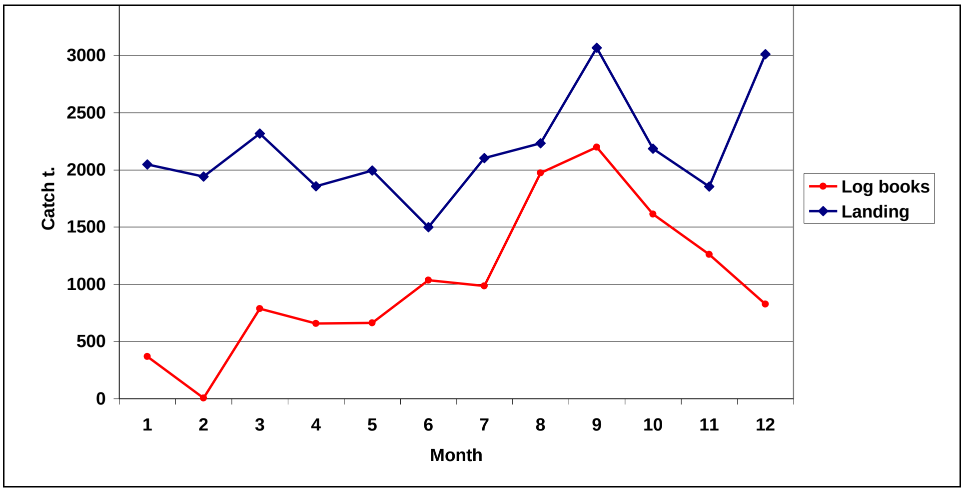


Figure 18. Average monthly catches recorded in the P-Fleet log books during the 2006-2010 period, and average monthly total catches declared by the P-fleet during the same period.

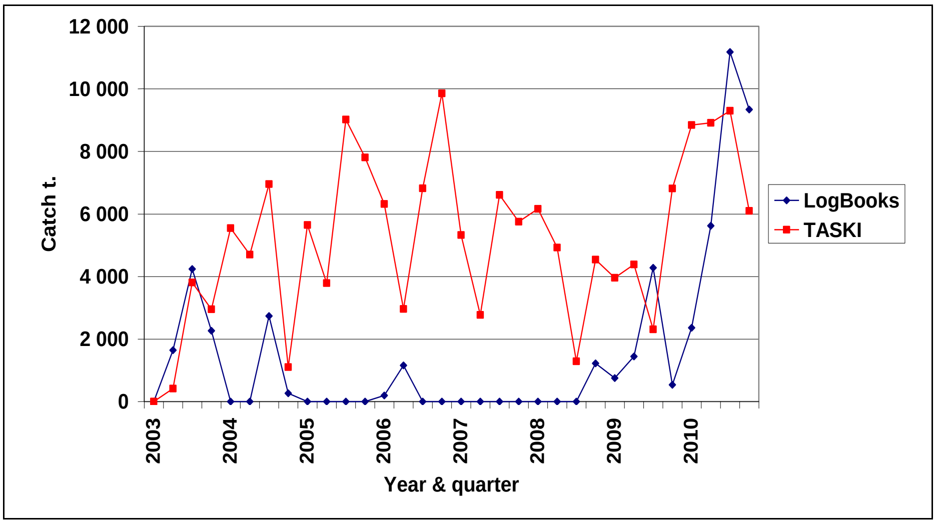


Figure 19. P-Fleet quarterly total catches: declared and covered by log books.

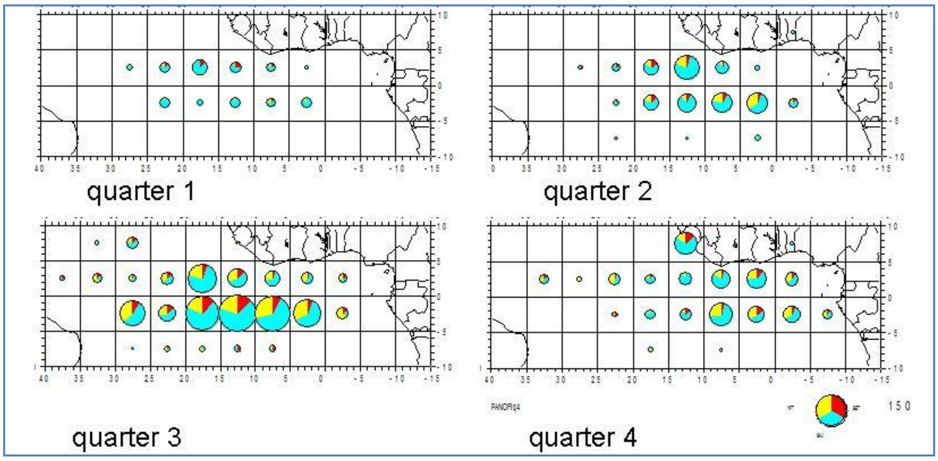


Figure 20. Average quarterly catches by species and by 5° squares, of the P-fleet during the 2003-2010 period based on its log books *(the variability of quarterly catches being due to the heterogeneity in the sampling rates of log books)*

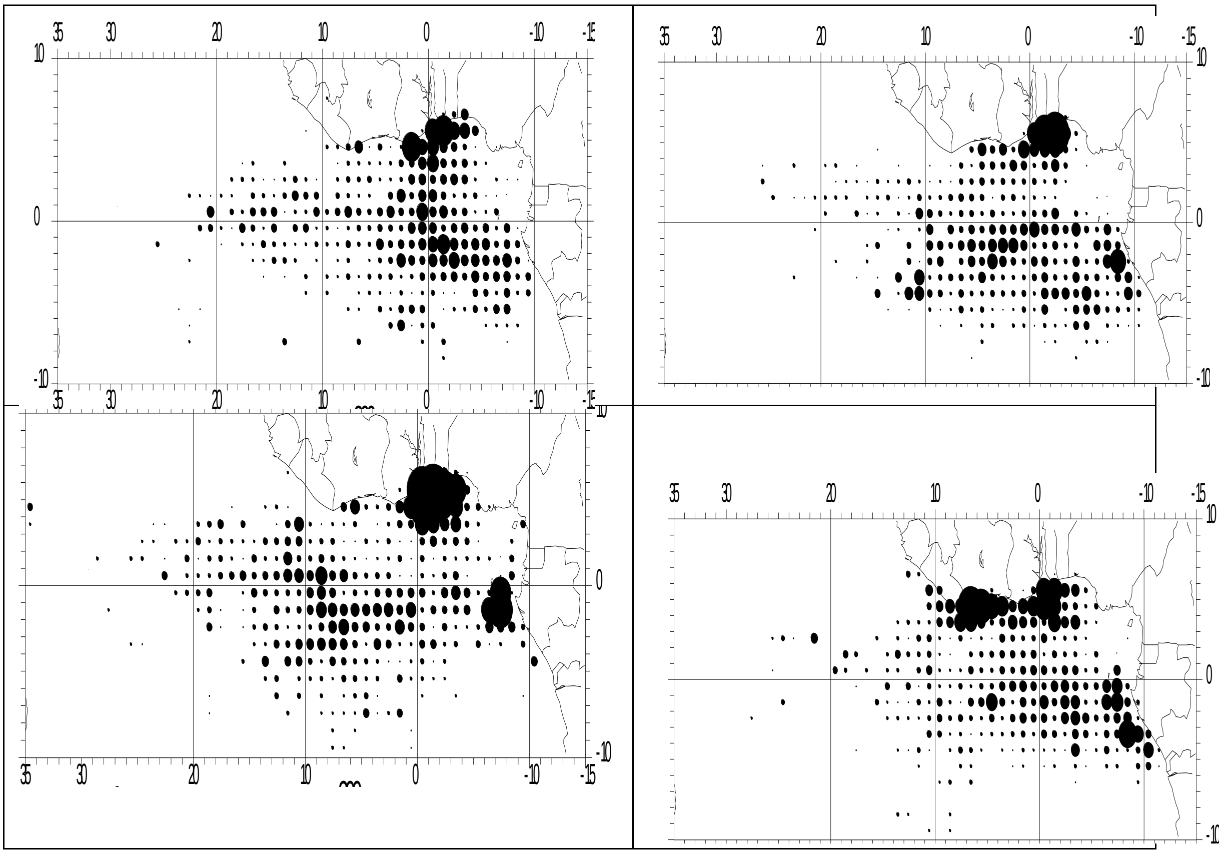


Figure 21. quarterly catches by 1° square of the A-fleet during the period 2006-2010 (upper panel: q1 left & q2 right, lower panel q3 left & q4 right)

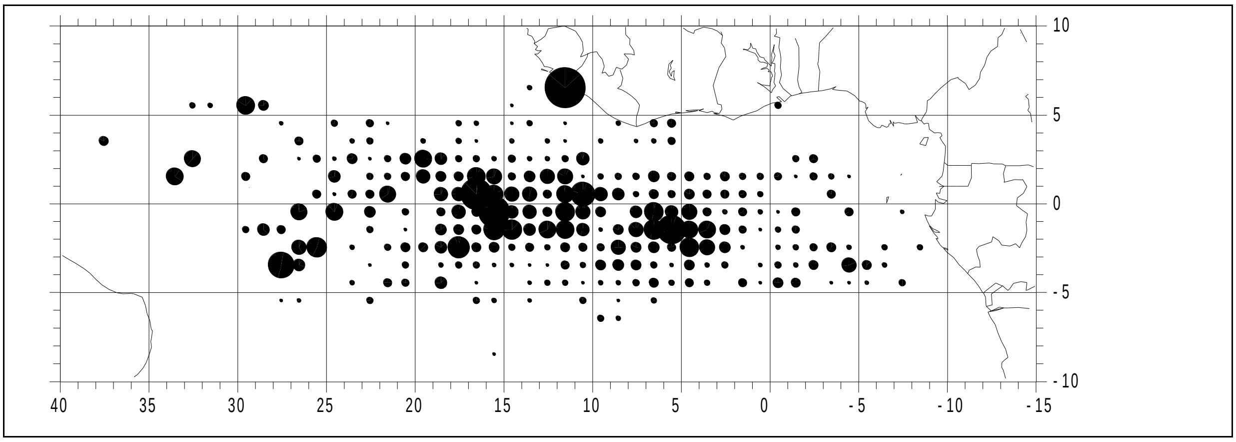


Figure 22. Average catches by 1° of the sampled P-Fleet log books during the 2006-2010 period used to estimate the fishing zones of this fleet

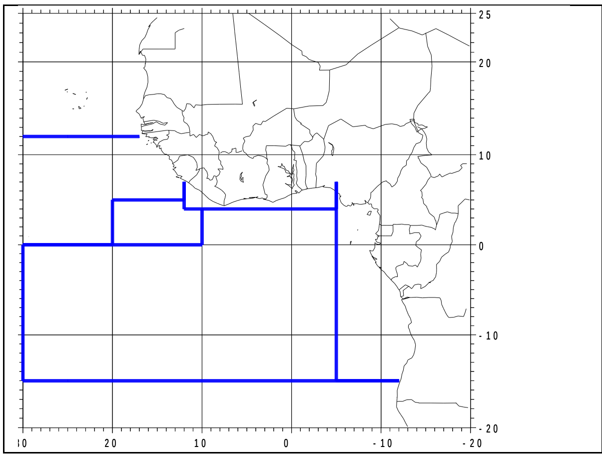


Figure 23. Statistical areas used since 1998 in the statistical analysis of **EU PS on FADs**

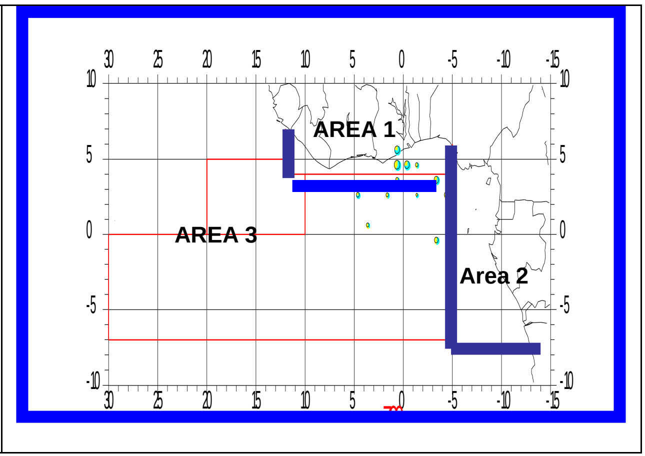


Figure 24. Geographical strata proposed for the Ghana TASK2 data processing 1996-2005

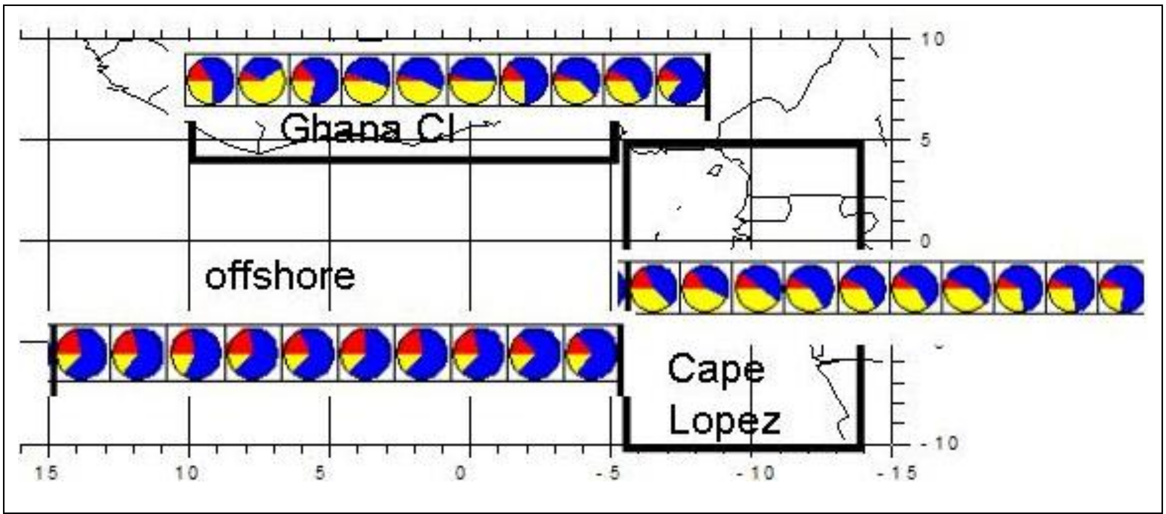


Figure 25. Average yearly species composition by area observed the EU PS catches on FADs during the studied period 1996-2005

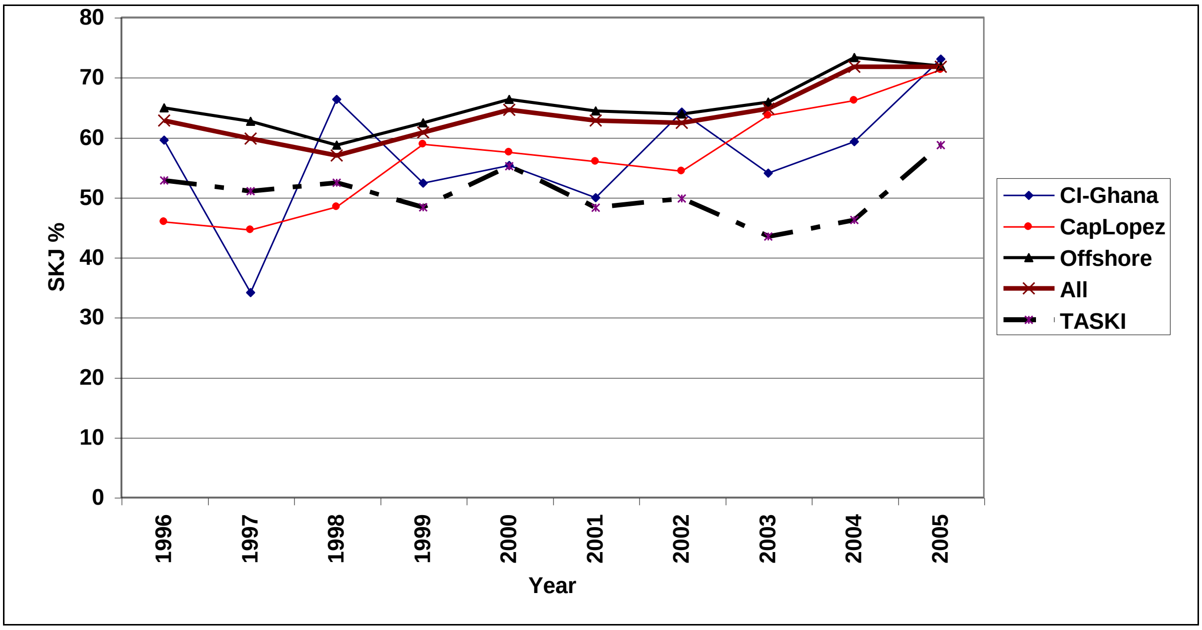


Figure 26a. Percentage of SKJ in the EU PS FAD catches in the 3 areas used in the Ghanaian data processing of the 1996-2005 period (compared to the % of SKJ in the Ghanaian TASK1)

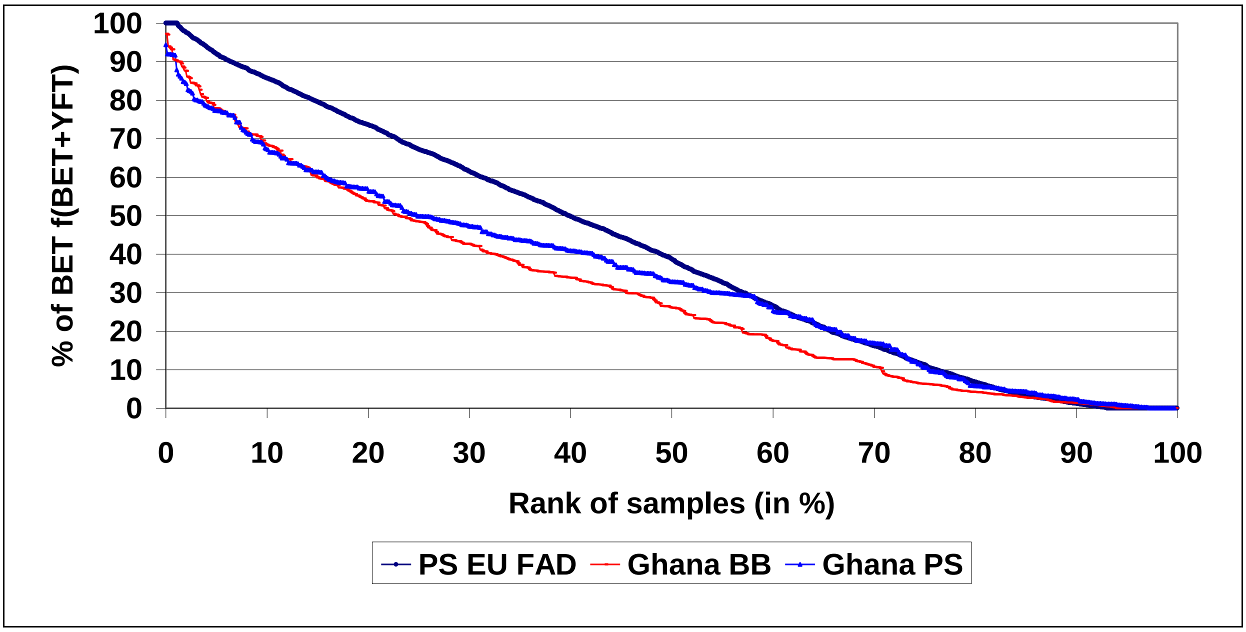
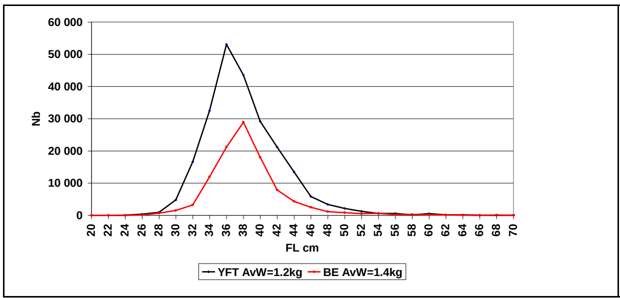


Figure 26b. Percentage of BET f (BET+YFT) in the size samples on Ghanaian BB &PS & on EU PS FAD, sorted by decreasing % of BET (2001-2010 period)



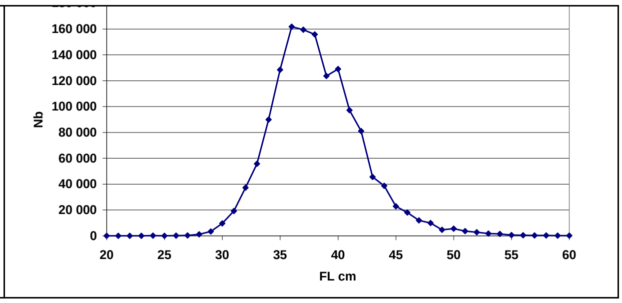


Figure 27 a. CAS of Ghanaian YFT and BET sampled in the Faux poisons market, 1996-2005

Figure 27 b. CAS of Ghanaian SKJ sampled in the Faux poisons market, 1996-2005 (av. Weight = 1.1 kg)

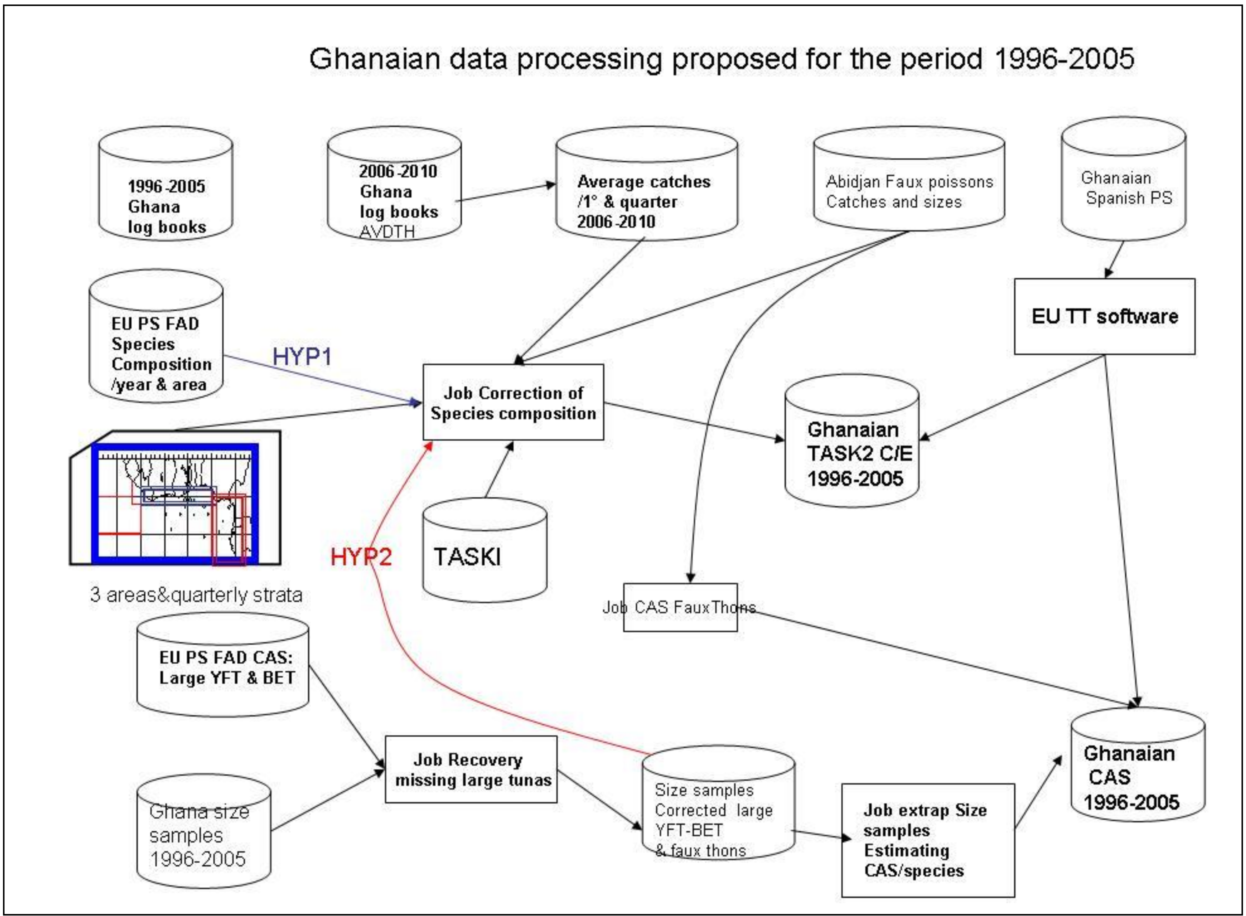
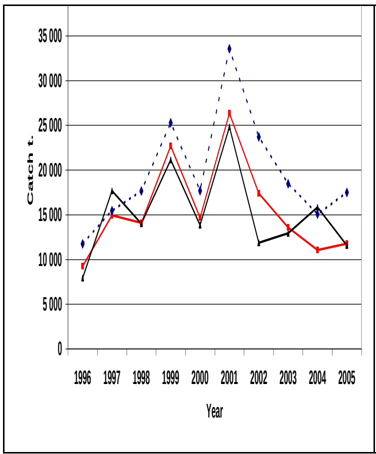
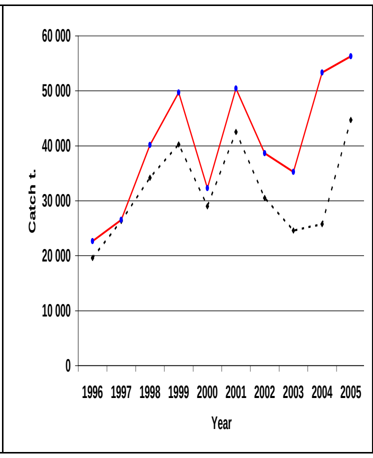


Figure 28. Flowchart of the data processing of the TASKI 2 Ghanaian data, catch & effort and catch at size, done during the period 1996-2005





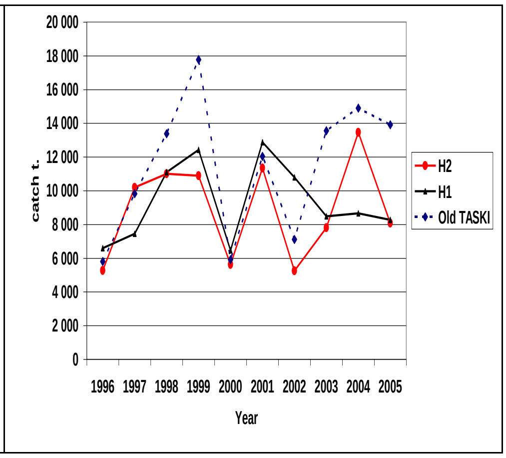
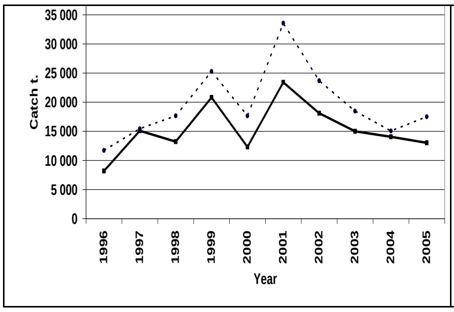
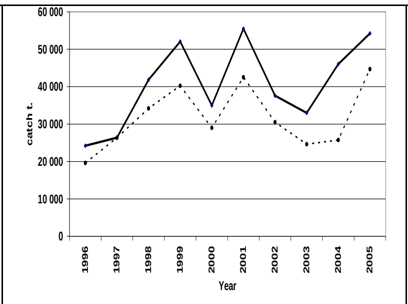


Figure 29a. Yearly catches of YFT: before (dotted line) and after the proposed revision (H1 & H2)

Figure 29b. Yearly catches of SKJ: before and after the proposed revision H1 & H2

Figure 29c. Yearly catches of BET: before and after the proposed revision H1 & H2





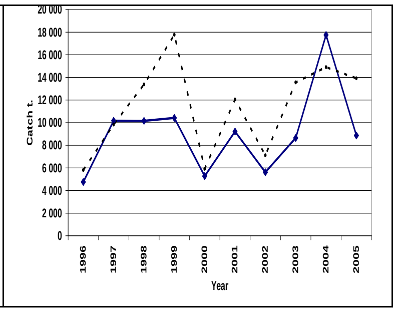
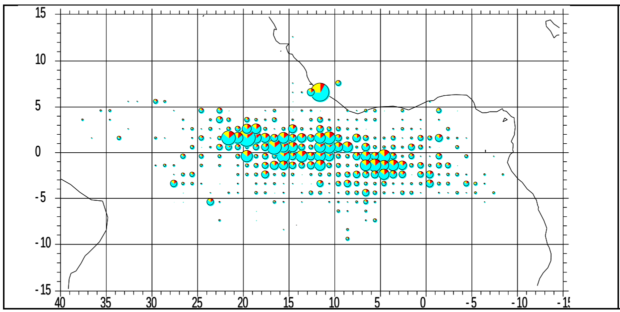


Figure 30a. Yearly catches of YFT, before (dotted line) and after the proposed revision in the H3 species composition hypothesis

Figure 30b. Yearly catches of SKJ, before (dotted line) and after the proposed revision in the H3 species composition hypothesis

Figure 30c. Yearly catches of BET, before (dotted line) and after the proposed revision in the H3 hypothesis



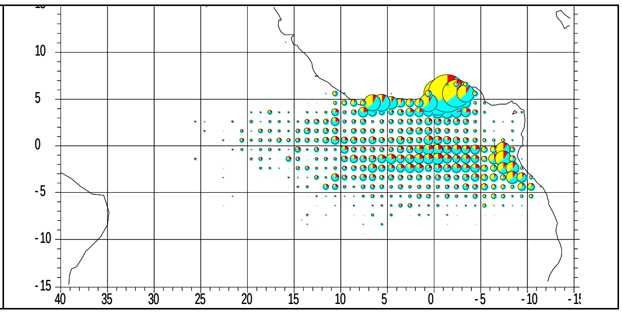


Figure 31a. Average catches by 1° square of the P-fleet during the 2003-2006 period

Figure 31b. Average catches by 1° square of the A-fleet during the 1996-2006 period

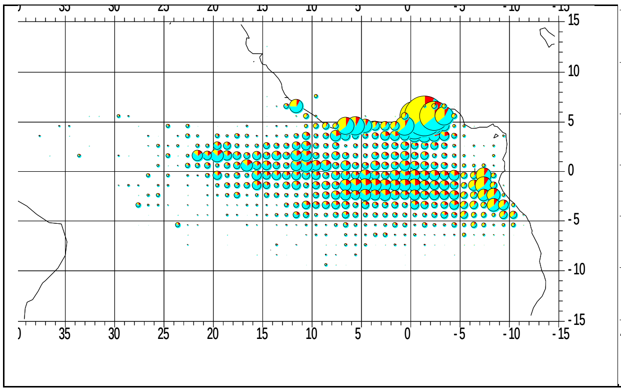


Figure 32. Average catches by 1° areas of the Ghanaian fleets during the period 1996-2005

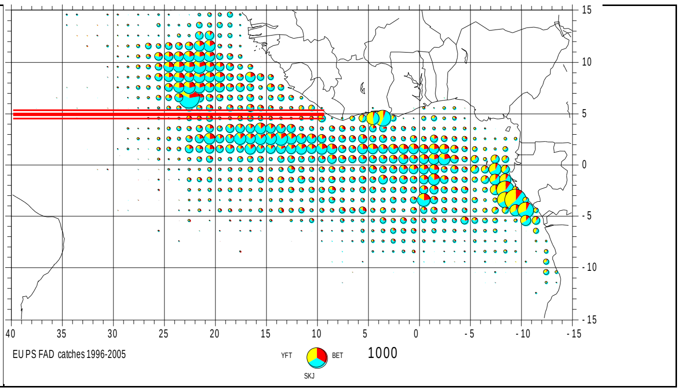


Figure 33. Average catches by 1° areas of the EU PS fleet on FADs during the period 1996-2005

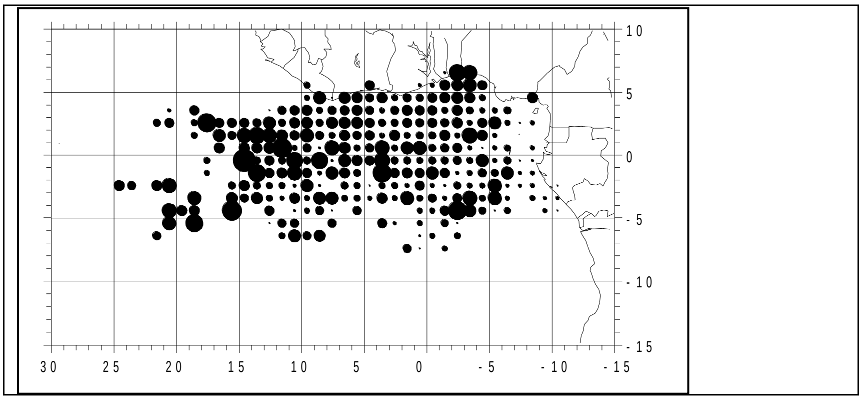


Figure 34. Average catches by 1° square of the available log book data, all Ghanaian fleet, during the period 1996-2005.

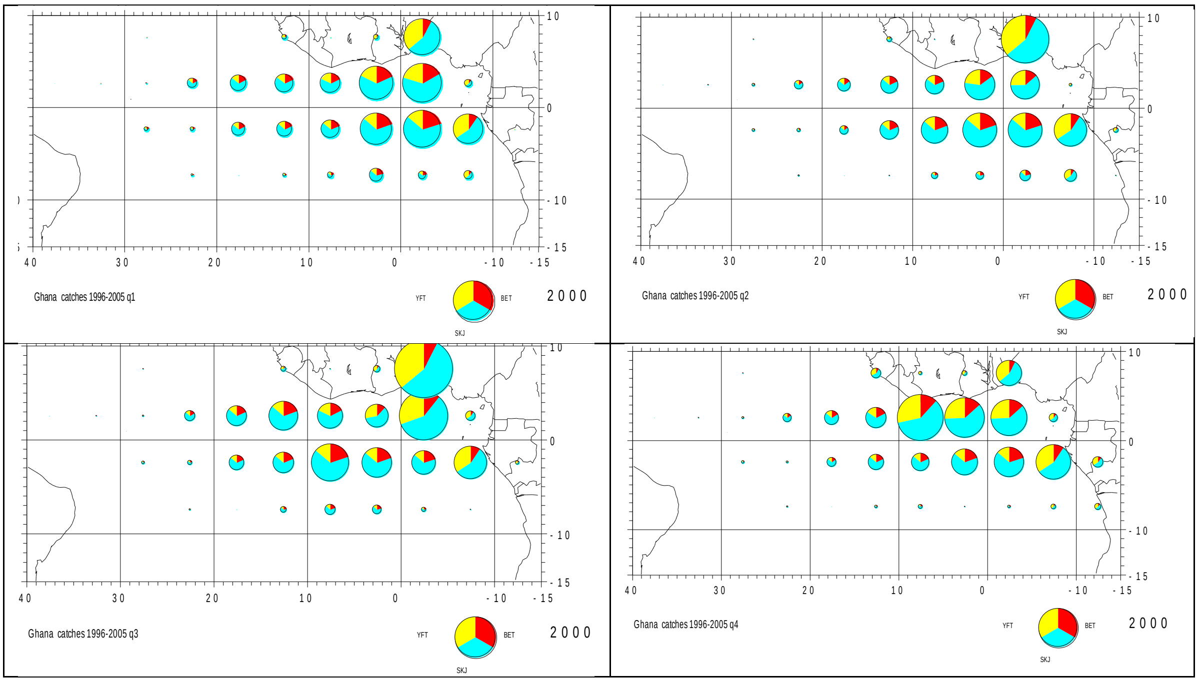


Figure 35. Average quarterly catches by 5° areas of the Ghanaian fleet during the 1996-2005 period

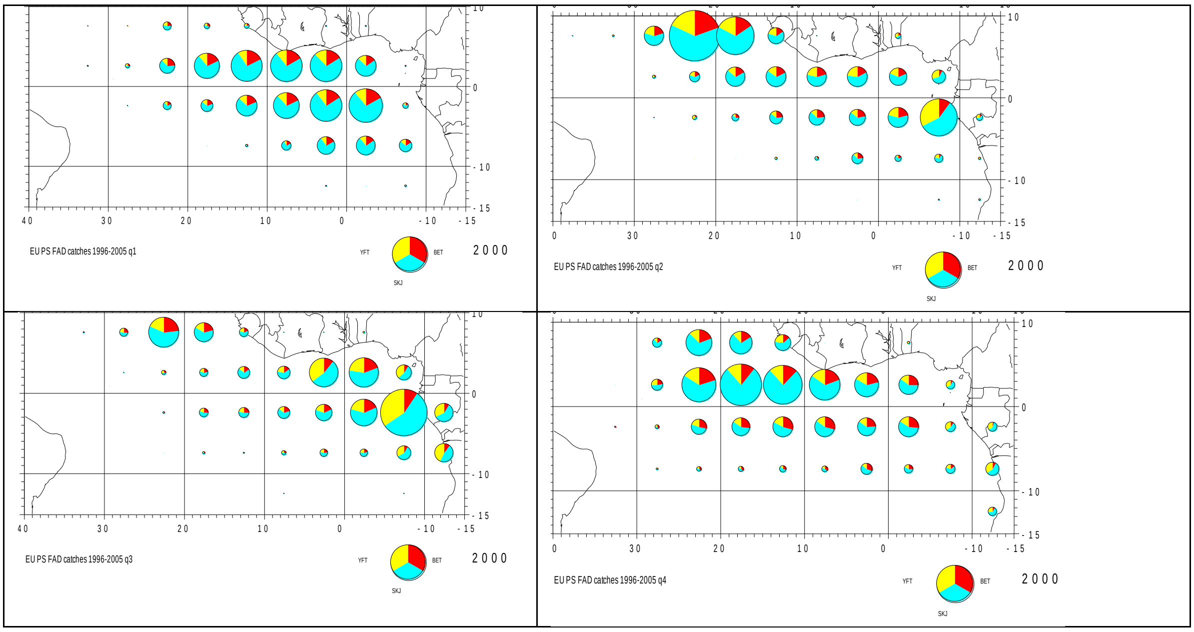
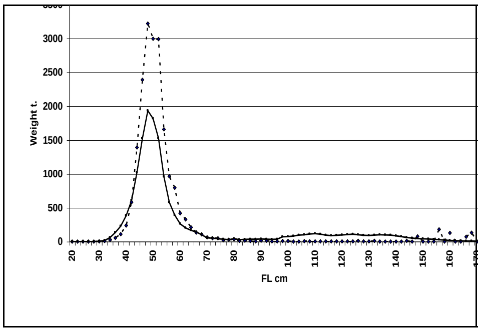
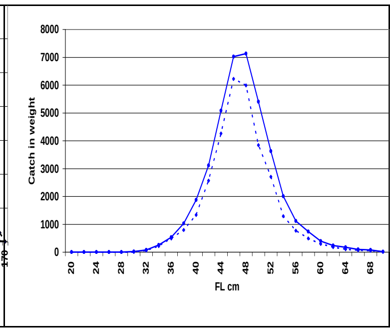


Figure 36. Average quarterly catches by 5° areas of the EU PS FAD fishery during the 1996-2005 period





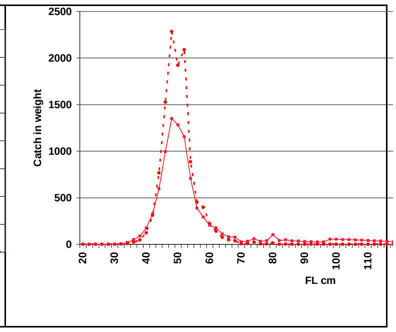
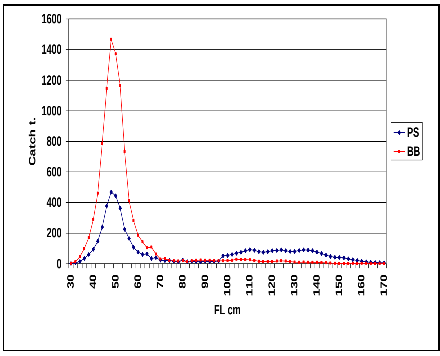
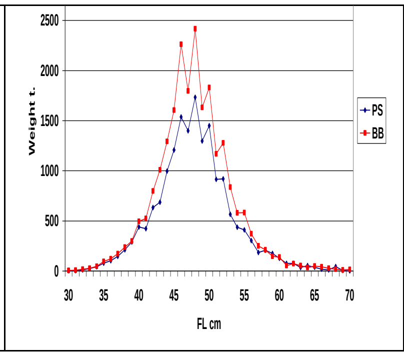


Figure 37a. Average catch at size of YFT, in weight, estimated before and in the H2 hypothesis

Figure 37b . Average catch at size of YFT, in weight, estimated before and in the H2 hypothesis

Figure 37c. Average catch at size of BET, in weight, estimated before and in the H2 hypothesis





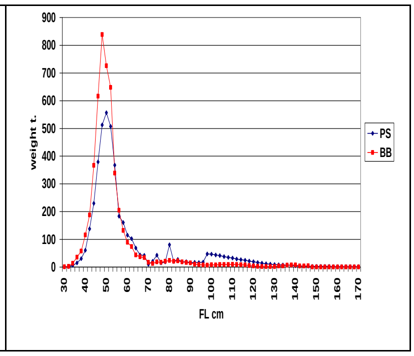
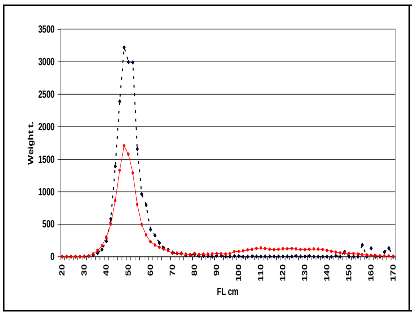
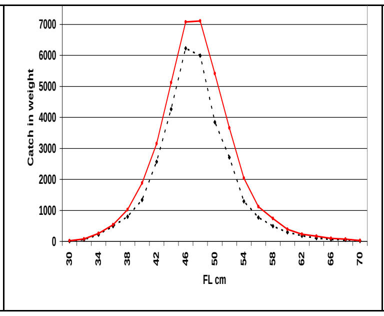


Figure 38a; Average CAS of YFT by Ghanaian BB & PS, 1996-2005; estimated in the H1 hypothesis (and ICCAT CAS) (bilanechantghana7310CAS.xls)

Figure 38b. Idem SKJ

Figure 38c. Idem BET





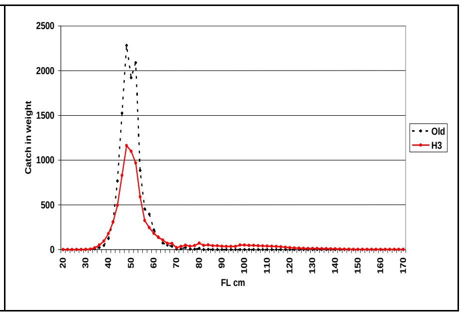


Figure 39a. Average CAS of YFT by Ghanaian BB & PS, 1996-2005; estimated in the H3 hypothesis (and ICCAT CAS, dotted line))

Figure 39b. Average CAS of SKJ by Ghanaian BB & PS, 1996-2005; estimated in the H3 hypothesis (and ICCAT CAS)

Figure 39c. Average CAS of BET by Ghanaian BB & PS, 1996-2005; estimated in the H3 hypothesis (and ICCAT CAS)

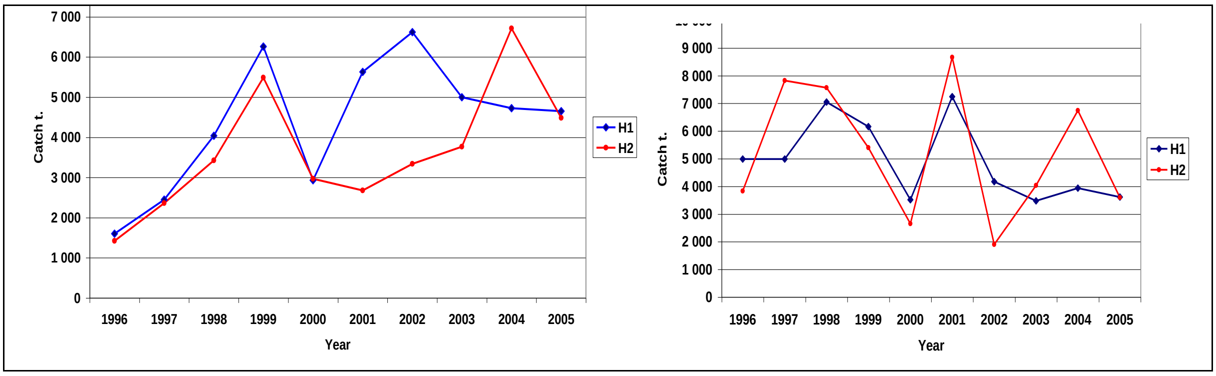
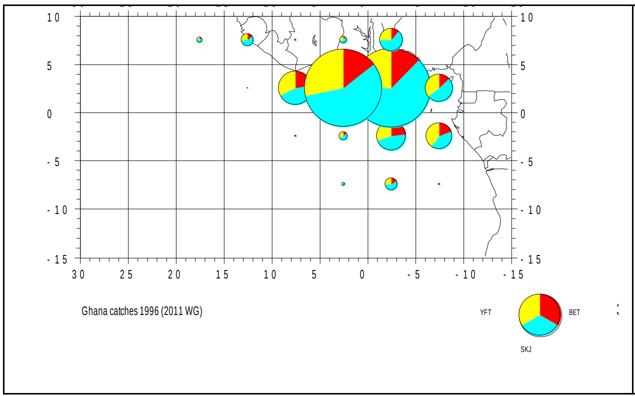


Figure 40. Yearly catches of BET by PS (left) and by BB (right) estimated in the 2 species composition H1 & H2



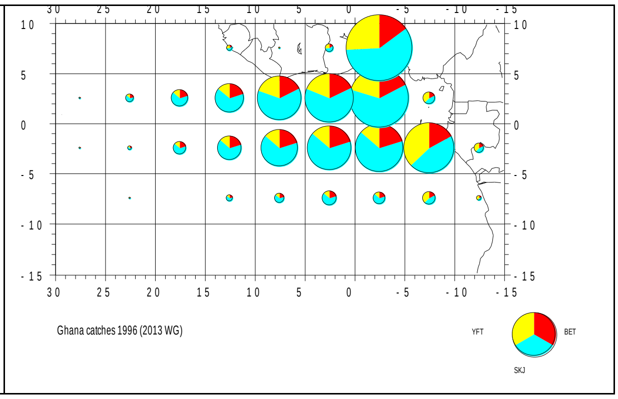


Figure 41a. Fishing map of the year 1996 estimated by the 2011 WG (scale=3000t.)

Figure 41b. Fishing map of the year 1996 estimated now

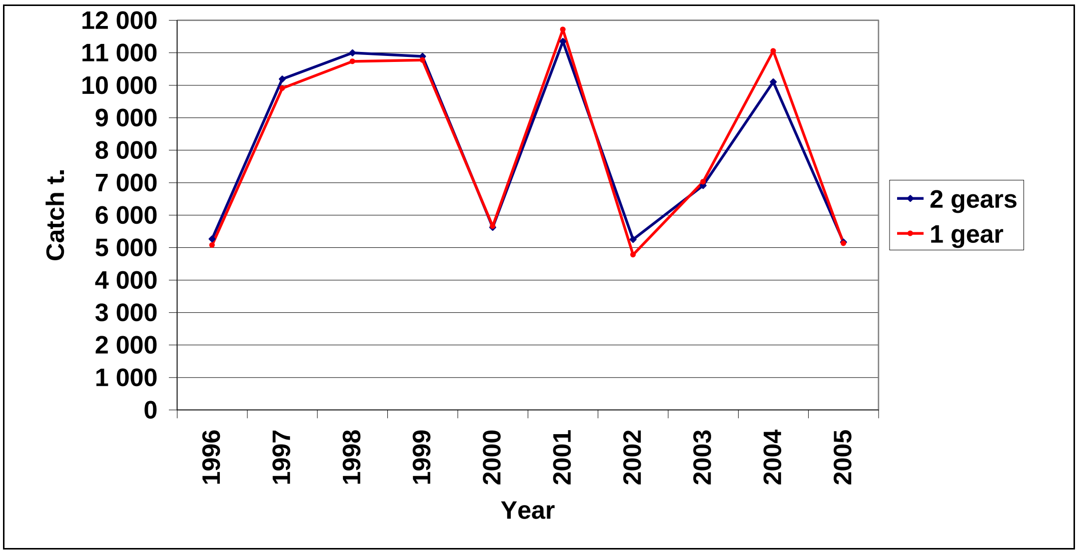
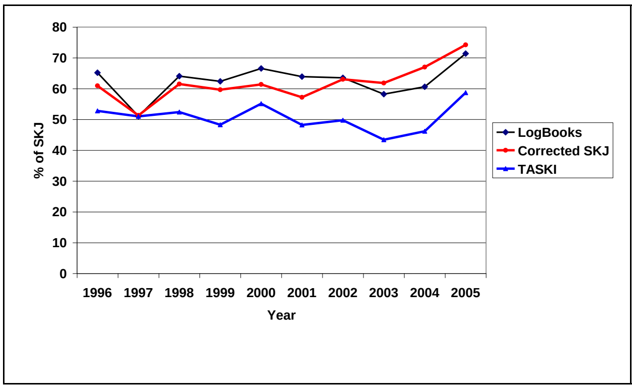


Figure 42. Yearly BET catches by species estimated for the A fleet based on a 1 and a 2 gears stratification during the studied period.



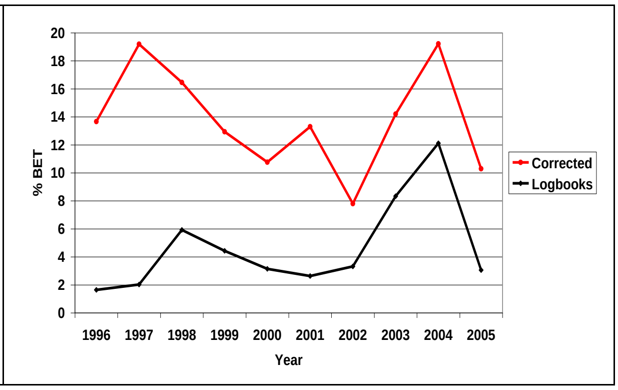


Figure 43a. Yearly percentages of SKJ in Ghanaian landing estimated from 3 sources

Figure 43b. Yearly percentages of BET in Ghanaian landing estimated in log books & after correction

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CATCH CHARACTERISTICS OF TROPICAL TUNA CAUGHT BY KOREAN TUNA LONGLINE FISHERY IN THE ATLANTIC OCEAN

Sang Chul Yoon[1], Zang Geun Kim, Sung Il Lee, Heewon Park, Dong Woo Lee

SUMMARY

The average of total catch by Korean tuna longline fishery in the Atlantic Ocean was about 3,200 mt from 1986 to 2011. Average catch proportion by species caught from 1986 to 2011 was 49.8% for bigeye tuna, 21.1% for yellowfin tuna. The average catch of bigeye tuna was about 1,800 mt and CPUE had recorded the highest at 9.1 inds./1,000 hooks in 2007. The average length distribution of bigeye tuna was 132.1cm, 132.9cm and 120.3cm in 2009, 2010 and 2011. The average catch of yellowfin tuna was about 590 mt and CPUE recorded the highest at 4.3 inds./1,000 hooks in 2000. The average length distribution of yellowfin tuna was 139.5cm, 131.1cm and 133.5cm in 2009, 2010 and 2011. The fishing ground for bigeye tuna and yellowfin tuna was mainly formed from the north of 20°N to the south of 10°S from 2007 to 2008. In this study, we would like to introduce the catch characteristics of tropical tuna caught by Korean longline fishery in Atlantic Ocean, and these results will be used as fundamental data for fisheries management and stock assessment.

RÉSUMÉ

Entre 1986 et 2011, la prise moyenne totale de la pêcherie palangrière coréenne de thonidés opérant dans l'océan Atlantique s'est élevée à environ 3.200 t. La proportion moyenne des captures par espèce capturée entre 1986 et 2011 s'établissait à 49,8% pour le thon obèse et 21,1% pour l'albacore. La prise moyenne de thon obèse se chiffrait à environ 1.800 t et la CPUE a atteint son point culminant à 9,1 spécimens/1.000 hameçons en 2007. La distribution des tailles moyennes du thon obèse s'est établie à 132,1 cm, 132,9 cm et 120,3 cm en 2009, 2010 et 2011. La prise moyenne d'albacore se chiffrait à environ 590 t et la CPUE a atteint son point culminant à 4,3 spécimens/1.000 hameçons en 2000. La distribution des tailles moyennes de l'albacore s'est établie à 139,5cm, 131,1cm et 133,5cm en 2009, 2010 et 2011. La zone de pêche du thon obèse et de l'albacore s'étendait essentiellement du Nord de 20ºN au Sud de 10ºS de 2007 à 2008. Dans cette étude, nous souhaitons présenter les caractéristiques de la prise des thonidés tropicaux capturés par la pêcherie palangrière coréenne opérant dans l'océan Atlantique, et ces résultats seront utilisés comme données de base pour la gestion des pêcheries et l'évaluation des stocks.

RESUMEN

La media de la captura total de la pesquería de palangre dirigida a los túnidos de Corea en el océano Atlántico fue de aproximadamente 3.200 t desde 1986 a 2011. La proporción de captura media por especies capturadas desde 1986 a 2011 fue de 49,8% para el patudo y 21,1% para el rabil. La captura media de patudo fue de alrededor de 1.800 t y la CPUE alcanzó el mayor valor en 9,1 ejemp./1.000 anzuelos en 2007. La distribución media de tallas de patudo fue de 132,1 cm, 132,9 cm y 120,3 cm en 2009, 2010 y 2011. La captura media de rabil fue de alrededor de 590 t y la CPUE alcanzó el mayor valor en 4,3 ejemp./1.000 anzuelos en 2000. La distribución media de tallas de patudo fue de 139,5 cm, 131,1cm y 133,5 cm en 2009, 2010 y 2011. El caladero de patudo y de rabil ocupaba principalmente el área desde el norte de 20ºN hasta el sur de 10º S desde 2007 a 2008. En este estudio, deseamos introducir las características de la captura de los túnidos tropicales capturados por la pesquería de palangre de Corea en el océano Atlántico y estos resultados se utilizarán como datos fundamentales para la ordenación pesquera y la evaluación de stock.

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KEYWORDS

Korean tuna longline, Catch, CPUE, Distribution, Range of length

1 Introduction

Korean distant water tuna longline fishery commenced in 1957 in the Indian Ocean and expanded to the Pacific Ocean in 1958 and the Atlantic Ocean in early 1960s. Since then, it has become one of the most important fisheries in Korea together with the domestic fisheries. In Atlantic Ocean, number of active longline fishing vessels showed a decreasing tendency overall, the number of longline fishing vessels had increased to 24 in 2008. In recent years, number of longline fishing vessels was 16 in Atlantic Ocean in 2011. The major species were bigeye tuna, yellowfin tuna, and albacore tuna (**Table 1**). In this study, we would like to introduce the catch characteristics of tropical tuna species caught by Korean longline fishery in the Atlantic Ocean using the catch data and fishery information compiled from logbook, distribution of its fishing ground and length distribution, and to give the information being useful for stock assessment of this species.

2 Data and Methods

The nominal catch data by species for Korean tuna longline fishery in the Atlantic Ocean (KOFA, 1987-2012) were used to investigate catch characteristics of major tunas caught by Korean tuna longline fishery in the Atlantic Ocean. Catch per unit effort (CPUE) of major tunas caught by Korean longline fishery was estimated using catch by species and effort (number of hooks) data aggregating from logbook by year, and its distribution of fishing grounds was indicated. Length frequency of major tunas was analyzed using observer data and fisherman data measured onboard.

3 Results

3.1 Catch of Korean tuna longline fishery

The average of total catch by Korean tuna longline fishery in the Atlantic Ocean was about 3,200 mt from 1986 to 2011. The catch recorded the highest at 13,000 mt in 1989, and then it had decreased to the lowest at 97 mt in 2002 and then it had been increased, it showed around 4,600 mt in 2011. In recent years, it had shown an increasing trend. CPUE of Korean tuna longline fishery in the Atlantic Ocean had started to increase since 2001, and recorded the highest at 13.8inds./1,000 hooks in 2005. After then, it has shown a decreasing trend (**Figure 1**).

Average catch proportion by species caught by Korean tuna longline fishery in the Atlantic Ocean from 1986 to 2011 was 49.8% for bigeye tuna which was the highest, 21.1% for yellowfin tuna, 6.1% for bluefin tuna and 5.3% for southern bluefin tuna and 3.0% for albacore tuna. Catch proportion by species was 59.9% for bigeye tuna which was the highest, 10.6% for yellowfin tuna, 2.8% for albacore tuna in 2011 (**Figure 2**). **Figure 3** shows the spatial distribution of fishing ground of Korean tuna longline fishery in the Atlantic Ocean. The fishing ground was formed mainly from the north of 20°N to the south of 10°S from 2007 to 2008. And it expanded to the south of 50°S in 2009 and 2011.

3.2 Catch characteristics of tropical tuna caught by Korean tuna longline fishery

3.2.1 Bigeye tuna

The average of bigeye tuna catch by Korean tuna longline fishery in the Atlantic Ocean was about 1,800 mt from 1986 to 2011. The catch recorded the highest at 7,900 t in 1989, and then it had decreased to the lowest at 1 mt in 2001 and then it had been increased, it showed around 2,700 t in 2011.CPUE of bigeye tuna in the Atlantic Ocean had started to increase since 2001, and recorded the highest at 9.1inds./1,000 hooks in 2007. After then, it has shown a decreasing trend (**Figure. 4**).

Figure 5 shows the recent monthly average catches of bigeye tuna caught by Korean tuna longline fishery in the Atlantic Ocean. It shows the lowest level of 100 t in July and the highest level of 290 t in January.

Figure 6 shows the spatial distribution of fishing ground of bigeye tuna caught by Korean tuna longline fishery in the Atlantic Ocean. The fishing ground for bigeye tuna was formed mainly from the north of 20°N to the south of 10°S from 2007 to 2008. And it expanded to the south of 50°S in 2009. Formation pattern of fishing ground was similar with spatial distribution of Korean tuna longline fishery in the Atlantic Ocean.

The length distribution of bigeye tuna caught by Korean tuna longline fishery in the Atlantic Ocean was shown that the range of length was 95-205cm (mean 132.1cm) in 2009,71-244cm (mean 132.9cm) in 2010, 63-287cm (mean 120.3cm) in 2011, respectively. The main mode of length was 117cm of 2009, 135cm of 2010, and 119cm of 2011 (**Figure 7**).

3.2.2 Yellowfin tuna

The average of yellowfin tuna catch by Korean tuna longline fishery in the Atlantic Ocean was about 590mt from 1986 to 2011. The catch recorded the highest at 2,500 mt in 1989, and then it had decreased to the lowest at 3mt in 2001 and then it had been increased, it showed around 490mt in 2011. CPUE of yellowfin tuna in the Atlantic Ocean recorded the highest at 4.3inds./1,000 hooks in 2000. After then, it has shown a decreasing trend (**Figure 8**).

Figure 9 shows the recent monthly average catches of yellowfin tuna caught by Korean tuna longline fishery in the Atlantic Ocean. It shows the lowest level of 29 t in April and the highest level of 68 t in February. Since May, monthly average catches did not show large fluctuation.

Figure 10 shows the spatial distribution of fishing ground of yellowfin tuna caught by Korean tuna longline fishery in the Atlantic Ocean. The fishing ground for yellowfin tuna was formed mainly from the north of 20°N to the south of 10°S from 2007 to 2008. And it expanded to the south of 50°S in 2009. Formation pattern of fishing ground was similar with spatial distribution of Korean tuna longline fishery in the Atlantic Ocean.

The length distribution of yellowfin tuna caught by Korean tuna longline fishery in the Atlantic Ocean was shown that the range of length was 101-183cm (mean 139.5cm) in 2009, 93-170cm (mean 131.1cm) in 2010, 76-179cm (mean 133.5cm) in 2011, respectively. The main mode of length was 123 cm and 125cm of 2009, 115cm of 2010, and there were 3 modes of length was128cm, 154cm and 163cm of 2011, respectively (**Figure 11**).

References

KOFA (Korea Overseas Fisheries Association).1987-2012. Statistical year book of overseas. 394pp.

Table 1. Nominal catch (t) of tropical tuna caught by Korean longline in the Atlantic Ocean, 1986-2011.

Year	*No. of vessels*	*BFT*	*YFT*	*ALB*	*BET*	*SBF*	*SKJ*	*OTH*	*Total*
1986	28	-	1,818	694	6,084	-	11	1,289	9,896
1987	29	-	1,457	401	4,438	-	6	1,283	7,585
1988	29	-	1,368	196	4,919	-	3	1,454	7,940
1989	33	-	2,535	107	7,896	-	6	2,475	13,019
1990	17	-	808	53	2,690	-	-	717	4,268
1991	9	-	260	32	802	-	-	784	1,878
1992	8	-	219	5	866	-	-	192	1,282
1993	4	-	180	28	377	-	-	251	837
1994	4	688	436	3	386	-	-	320	1,833
1995	4	663	453	5	423	-	-	387	1,931
1996	16	683	381	20	1,250	-	-	424	2,758
1997	12	613	257	5	796	10	-	243	1,924
1998	5	66	23	7	163	10	-	16	285
1999	9	-	94	14	124	28	-	39	299
2000	9	6	142	18	43	61	-	14	284
2001	5	1	3	1	1	158	-	16	180
2002	-	-	8	-	87	-	-	2	97
2003	3	-	209	5	143	-	-	45	402
2004	11	3	984	37	629	-	-	113	1,766
2005	8	1	675	101	770	-	-	172	1,719
2006	8	79	283	111	2,067	-	-	245	2,785
2007	21	-	573	68	2,136	48	-	577	3,402
2008	24	-	993	147	2,599	229	-	567	4,535
2009	24	-	433	458	2,134	277	-	185	3,487
2010	14	-	380	240	2,646	1	-	565	3,832
2011	16	-	491	130	2,762	7	-	1,224	4,614

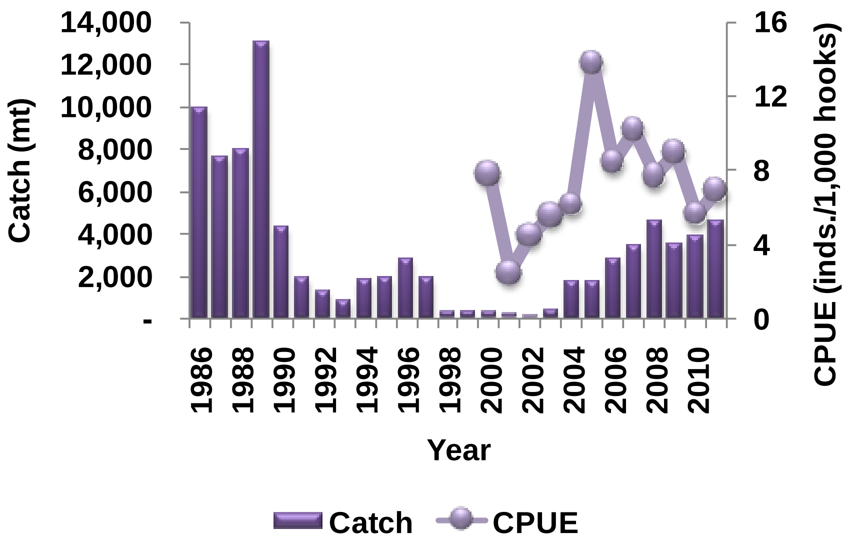

Figure 1. Variations in catches and CPUE of Korean tuna longline fishery in the Atlantic Ocean from1986 to 2011.

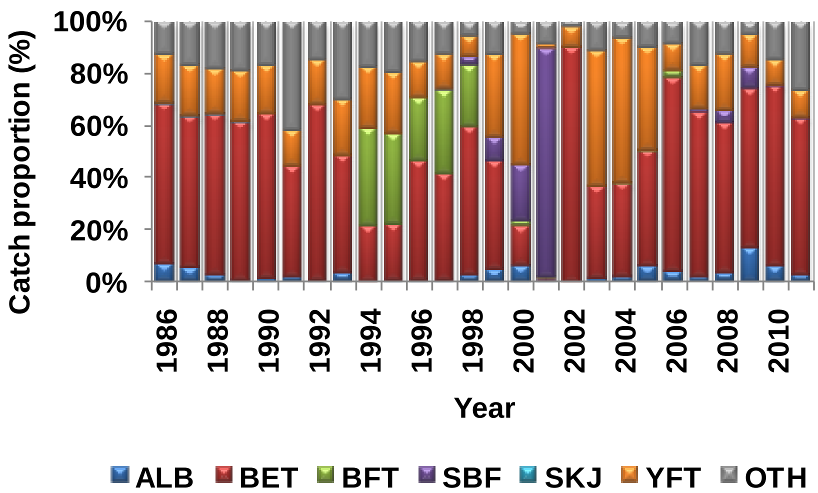

Figure 2. Catch proportion by species caught by Korean tuna longline fishery in the Atlantic Ocean from 1986 to 2011.

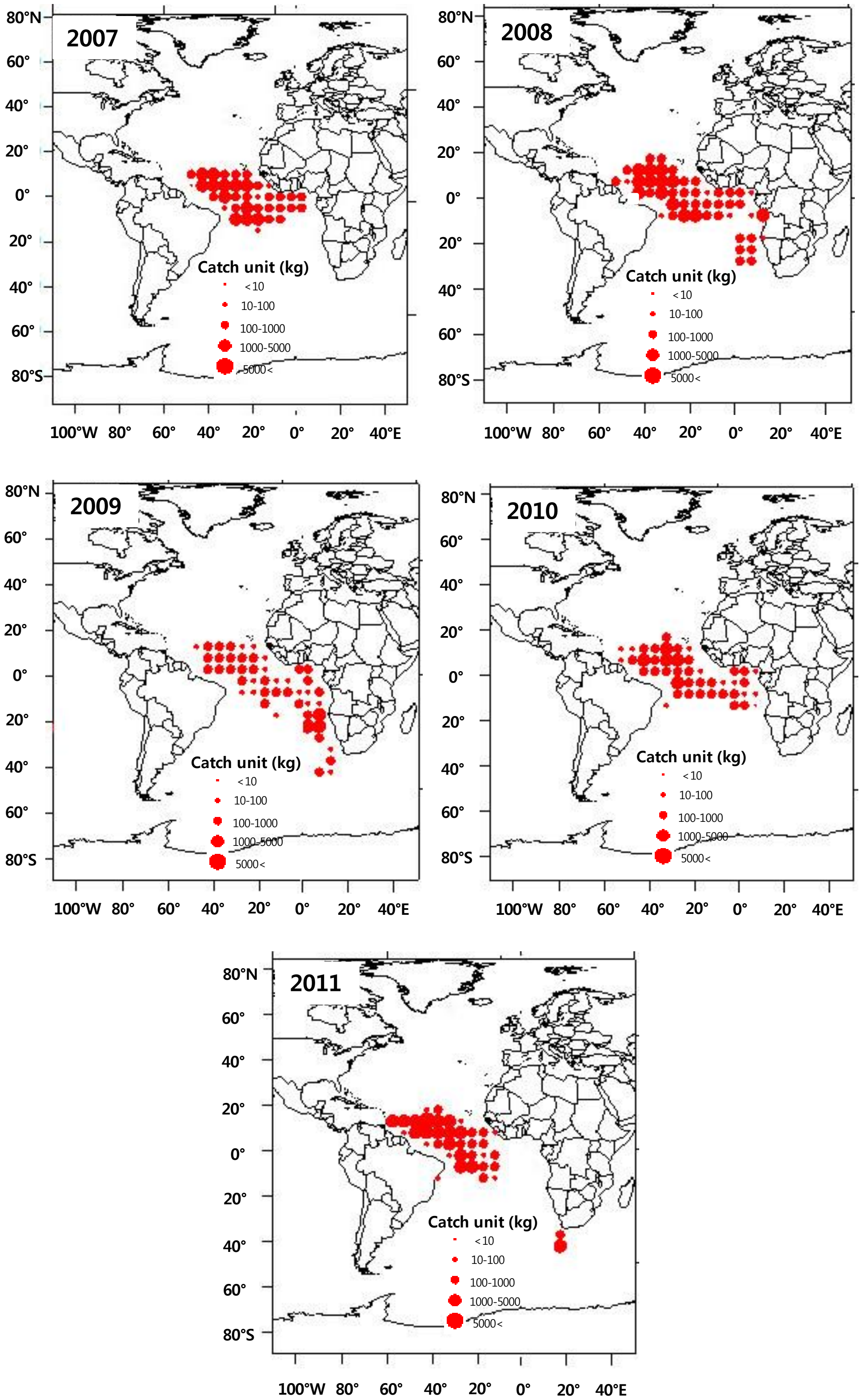

Figure 3. The spatial distributions of catch for Korean tuna longline fishery in the Atlantic Ocean for 5 recent years (2007-2011).

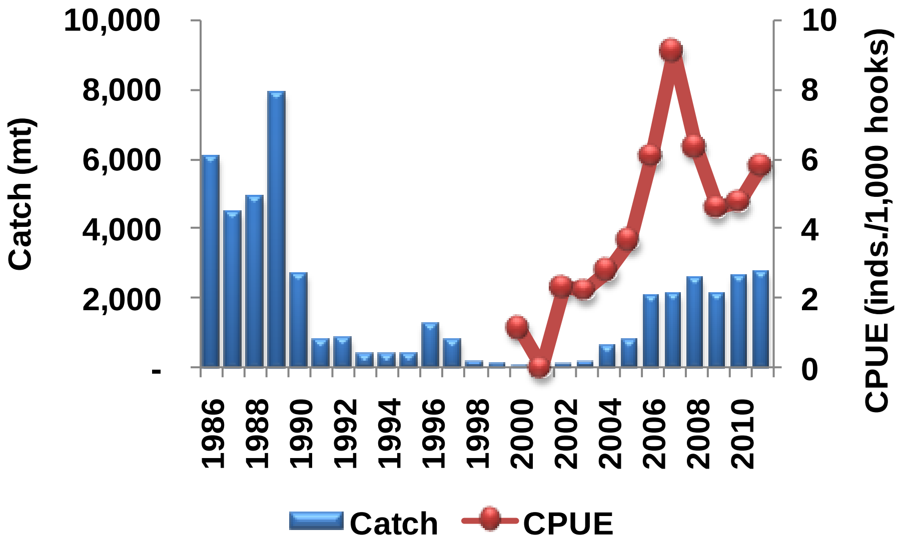

Figure 4. Variations in catches and CPUE of bigeye tuna caught by Korean tuna longline fishery in the Atlantic Ocean from 1986 to 2011.

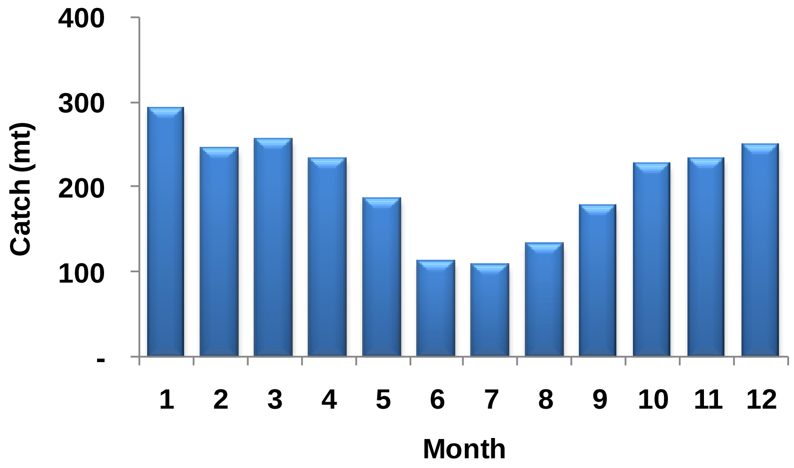

Figure 5. Monthly average catches of bigeye tuna caught by Korean tuna longline fishery in the Atlantic Ocean from 2007 to 2011.

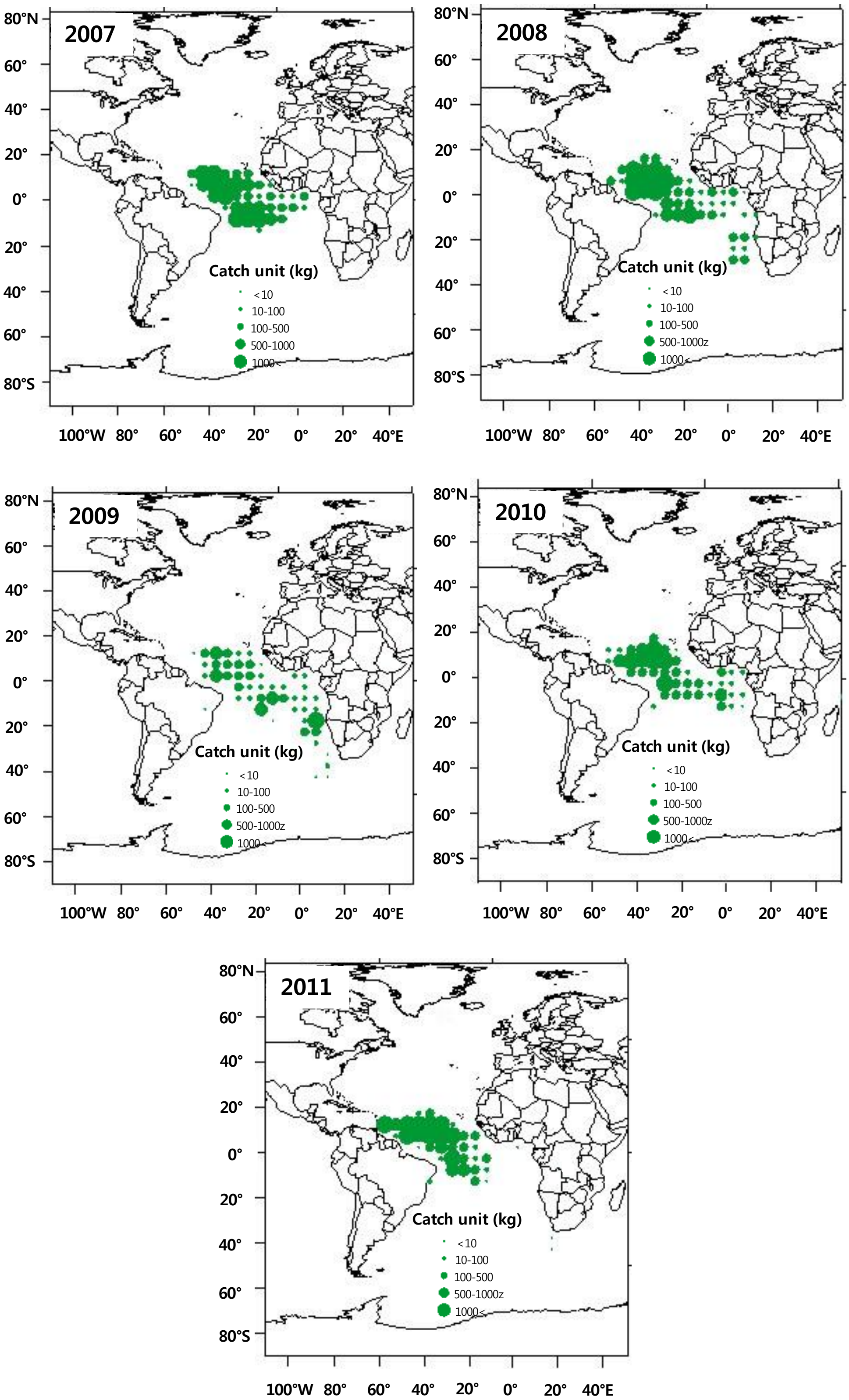

Figure 6. The spatial distributions of catch for bigeye tuna caught by Korean tuna longline fishery in the Atlantic Ocean for 5 recent years (2007-2011).

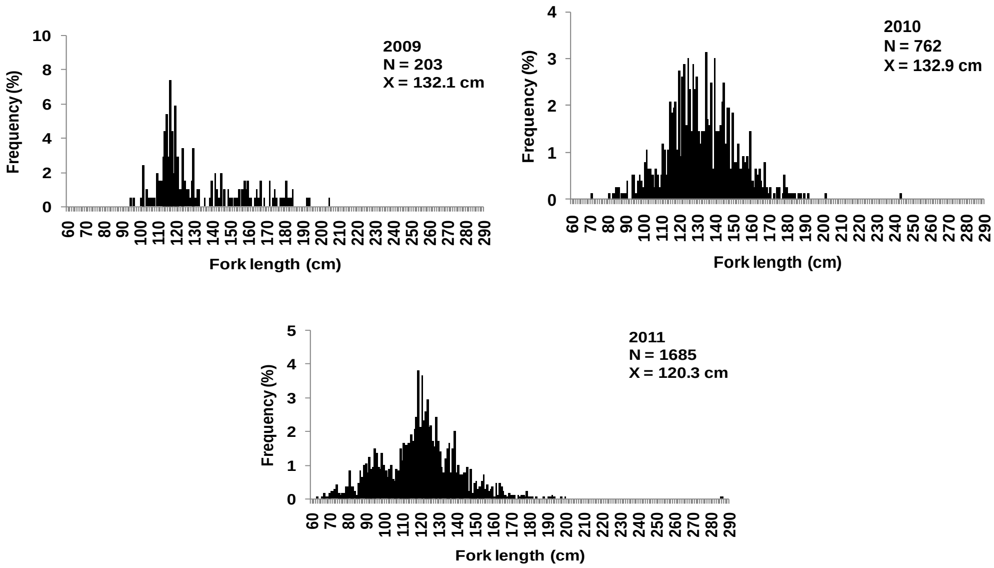

Figure 7. The length distribution of bigeye tuna caught by Korean tuna longline fishery in the Atlantic Ocean from 2009 to 2011.

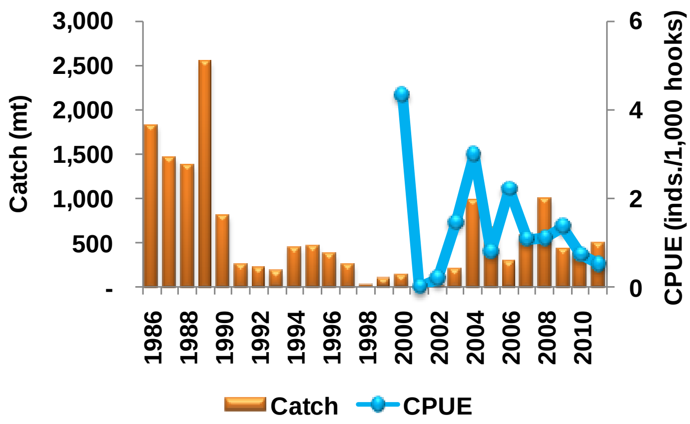

Figure 8. Variations in catches and CPUE of yellowfin tuna caught by Korean tuna longline fishery in the Atlantic Ocean from 1986 to 2011.

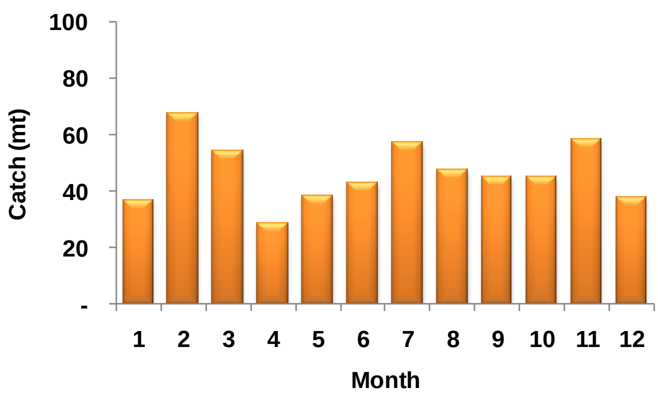

Figure 9. Monthly average catches of yellowfin tuna caught by Korean tuna longline fishery in the Atlantic Ocean from 2007 to 2011.

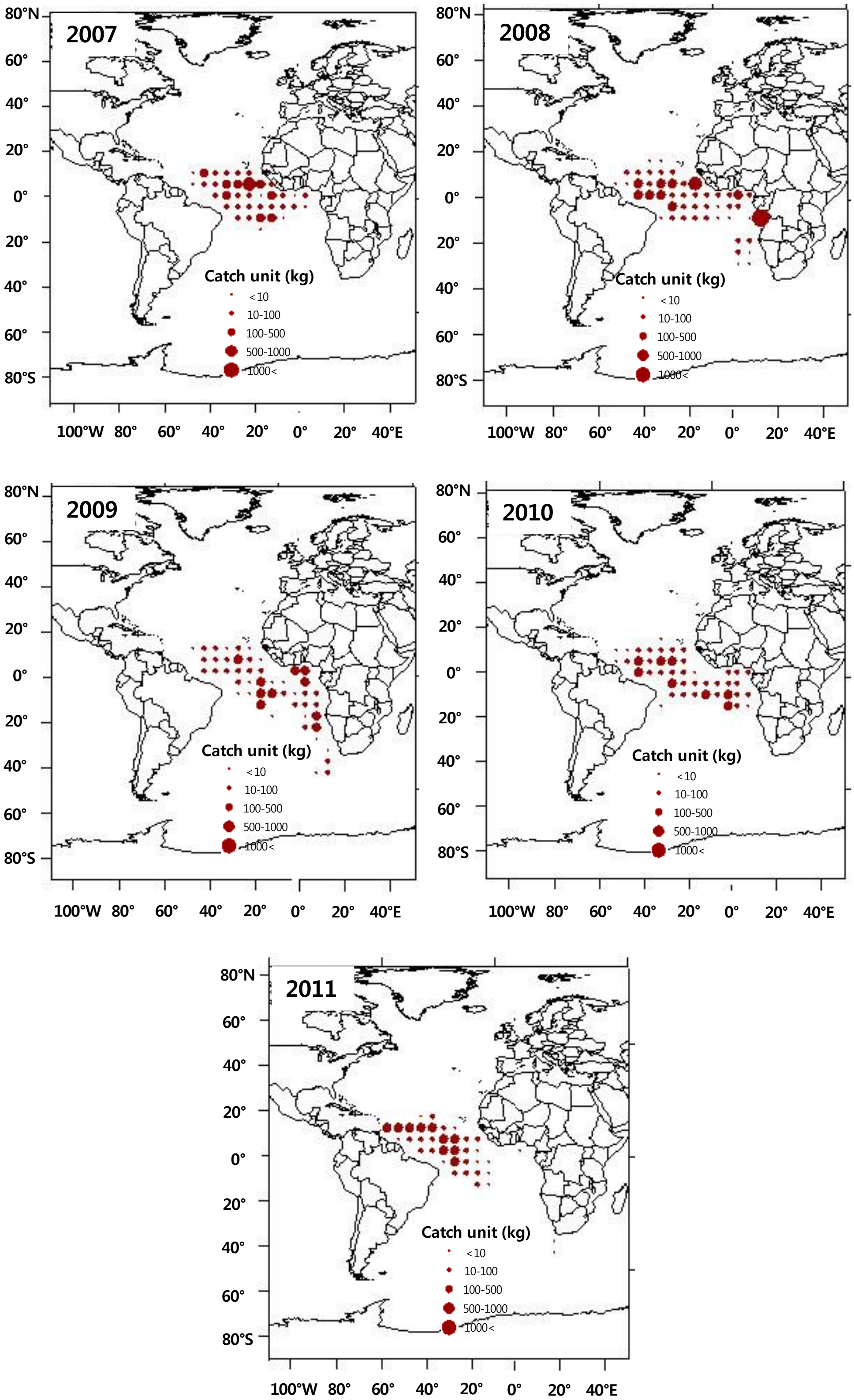

Figure 10. The spatial distributions of catch for yellowfin tuna caught by Korean tuna longline fishery in the Atlantic Ocean for 5 recent years (2007-2011).

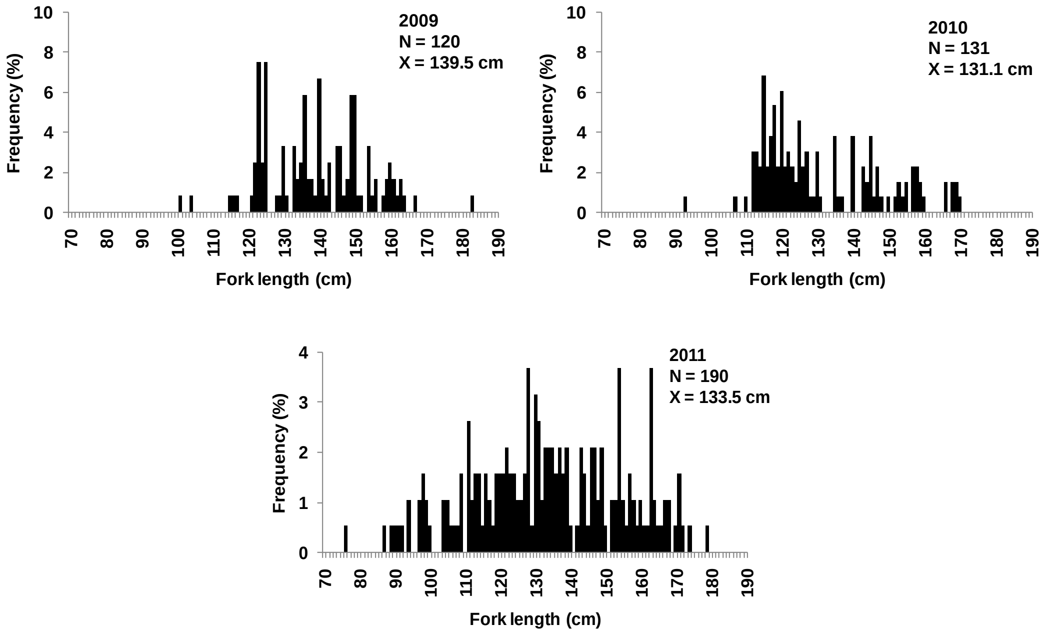

Figure 11. The length distribution of yellowfin tuna caught by Korean tuna longline fishery in the Atlantic Ocean from 2009 to 2011.

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RÉSUMÉ

Entre 1986 et 2011, la prise moyenne totale de la pêcherie palangrière coréenne de thonidés opérant dans l'océan Atlantique s'est élevée à environ 3.200 t. La proportion moyenne des captures par espèce capturée entre 1986 et 2011 s'établissait à 49,8% pour le thon obèse et 21,1% pour l'albacore. La prise moyenne de thon obèse se chiffrait à environ 1.800 t et la CPUE a atteint son point culminant à 9,1 spécimens/1.000 hameçons en 2007. La distribution des tailles moyennes du thon obèse s'est établie à 132,1 cm, 132,9 cm et 120,3 cm en 2009, 2010 et 2011. La prise moyenne d'albacore se chiffrait à environ 590 t et la CPUE a atteint son point culminant à 4,3 spécimens/1.000 hameçons en 2000. La distribution des tailles moyennes de l'albacore s'est établie à 139,5cm, 131,1cm et 133,5cm en 2009, 2010 et 2011. La zone de pêche du thon obèse et de l'albacore s'étendait essentiellement du Nord de 20ºN au Sud de 10ºS de 2007 à 2008. Dans cette étude, nous souhaitons présenter les caractéristiques de la prise des thonidés tropicaux capturés par la pêcherie palangrière coréenne opérant dans l'océan Atlantique, et ces résultats seront utilisés comme données de base pour la gestion des pêcheries et l'évaluation des stocks.

RESUMEN

La media de la captura total de la pesquería de palangre dirigida a los túnidos de Corea en el océano Atlántico fue de aproximadamente 3.200 t desde 1986 a 2011. La proporción de captura media por especies capturadas desde 1986 a 2011 fue de 49,8% para el patudo y 21,1% para el rabil. La captura media de patudo fue de alrededor de 1.800 t y la CPUE alcanzó el mayor valor en 9,1 ejemp./1.000 anzuelos en 2007. La distribución media de tallas de patudo fue de 132,1 cm, 132,9 cm y 120,3 cm en 2009, 2010 y 2011. La captura media de rabil fue de alrededor de 590 t y la CPUE alcanzó el mayor valor en 4,3 ejemp./1.000 anzuelos en 2000. La distribución media de tallas de patudo fue de 139,5 cm, 131,1cm y 133,5 cm en 2009, 2010 y 2011. El caladero de patudo y de rabil ocupaba principalmente el área desde el norte de 20ºN hasta el sur de 10º S desde 2007 a 2008. En este estudio, deseamos introducir las características de la captura de los túnidos tropicales capturados por la pesquería de palangre de Corea en el océano Atlántico y estos resultados se utilizarán como datos fundamentales para la ordenación pesquera y la evaluación de stock.

[1] National Fisheries Research and Development Institute (NFRDI), Busan, Korea, (E-mail: scyoon@korea.kr)

KEYWORDS

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1 Introduction

Korean distant water tuna longline fishery commenced in 1957 in the Indian Ocean and expanded to the Pacific Ocean in 1958 and the Atlantic Ocean in early 1960s. Since then, it has become one of the most important fisheries in Korea together with the domestic fisheries. In Atlantic Ocean, number of active longline fishing vessels showed a decreasing tendency overall, the number of longline fishing vessels had increased to 24 in 2008. In recent years, number of longline fishing vessels was 16 in Atlantic Ocean in 2011. The major species were bigeye tuna, yellowfin tuna, and albacore tuna (**Table 1**). In this study, we would like to introduce the catch characteristics of tropical tuna species caught by Korean longline fishery in the Atlantic Ocean using the catch data and fishery information compiled from logbook, distribution of its fishing ground and length distribution, and to give the information being useful for stock assessment of this species.

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3.2 Catch characteristics of tropical tuna caught by Korean tuna longline fishery

3.2.1 Bigeye tuna

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3.2.2 Yellowfin tuna

The average of yellowfin tuna catch by Korean tuna longline fishery in the Atlantic Ocean was about 590mt from 1986 to 2011. The catch recorded the highest at 2,500 mt in 1989, and then it had decreased to the lowest at 3mt in 2001 and then it had been increased, it showed around 490mt in 2011. CPUE of yellowfin tuna in the Atlantic Ocean recorded the highest at 4.3inds./1,000 hooks in 2000. After then, it has shown a decreasing trend (**Figure 8**).

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References

KOFA (Korea Overseas Fisheries Association).1987-2012. Statistical year book of overseas. 394pp.

Table 1. Nominal catch (t) of tropical tuna caught by Korean longline in the Atlantic Ocean, 1986-2011.

Year	*No. of vessels*	*BFT*	*YFT*	*ALB*	*BET*	*SBF*	*SKJ*	*OTH*	*Total*
1986	28	-	1,818	694	6,084	-	11	1,289	9,896
1987	29	-	1,457	401	4,438	-	6	1,283	7,585
1988	29	-	1,368	196	4,919	-	3	1,454	7,940
1989	33	-	2,535	107	7,896	-	6	2,475	13,019
1990	17	-	808	53	2,690	-	-	717	4,268
1991	9	-	260	32	802	-	-	784	1,878
1992	8	-	219	5	866	-	-	192	1,282
1993	4	-	180	28	377	-	-	251	837
1994	4	688	436	3	386	-	-	320	1,833
1995	4	663	453	5	423	-	-	387	1,931
1996	16	683	381	20	1,250	-	-	424	2,758
1997	12	613	257	5	796	10	-	243	1,924
1998	5	66	23	7	163	10	-	16	285
1999	9	-	94	14	124	28	-	39	299
2000	9	6	142	18	43	61	-	14	284
2001	5	1	3	1	1	158	-	16	180
2002	-	-	8	-	87	-	-	2	97
2003	3	-	209	5	143	-	-	45	402
2004	11	3	984	37	629	-	-	113	1,766
2005	8	1	675	101	770	-	-	172	1,719
2006	8	79	283	111	2,067	-	-	245	2,785
2007	21	-	573	68	2,136	48	-	577	3,402
2008	24	-	993	147	2,599	229	-	567	4,535
2009	24	-	433	458	2,134	277	-	185	3,487
2010	14	-	380	240	2,646	1	-	565	3,832
2011	16	-	491	130	2,762	7	-	1,224	4,614

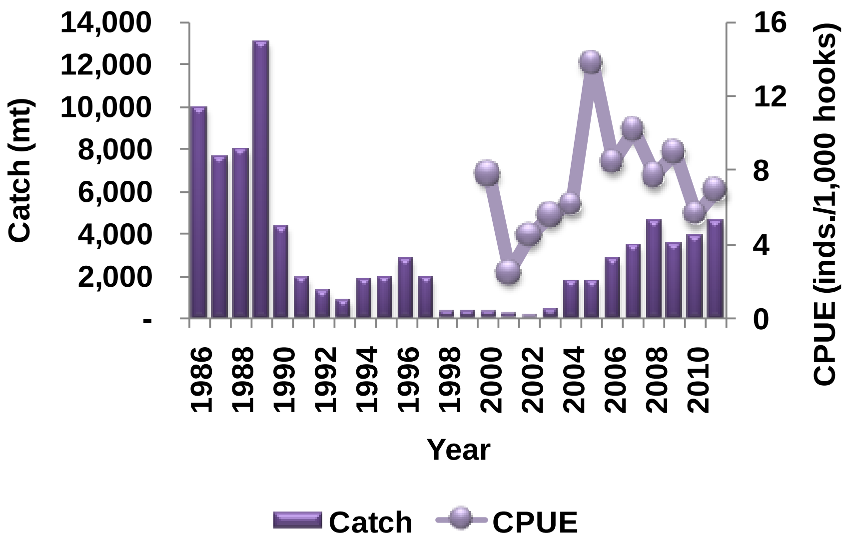

Figure 1. Variations in catches and CPUE of Korean tuna longline fishery in the Atlantic Ocean from1986 to 2011.

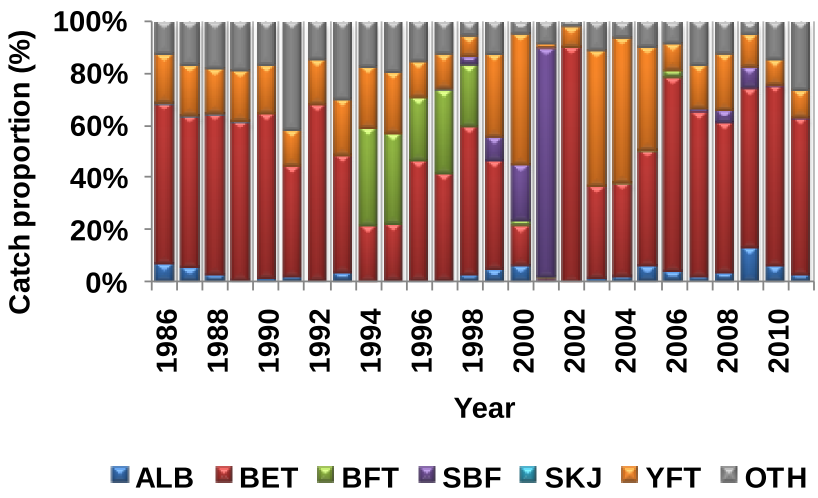

Figure 2. Catch proportion by species caught by Korean tuna longline fishery in the Atlantic Ocean from 1986 to 2011.

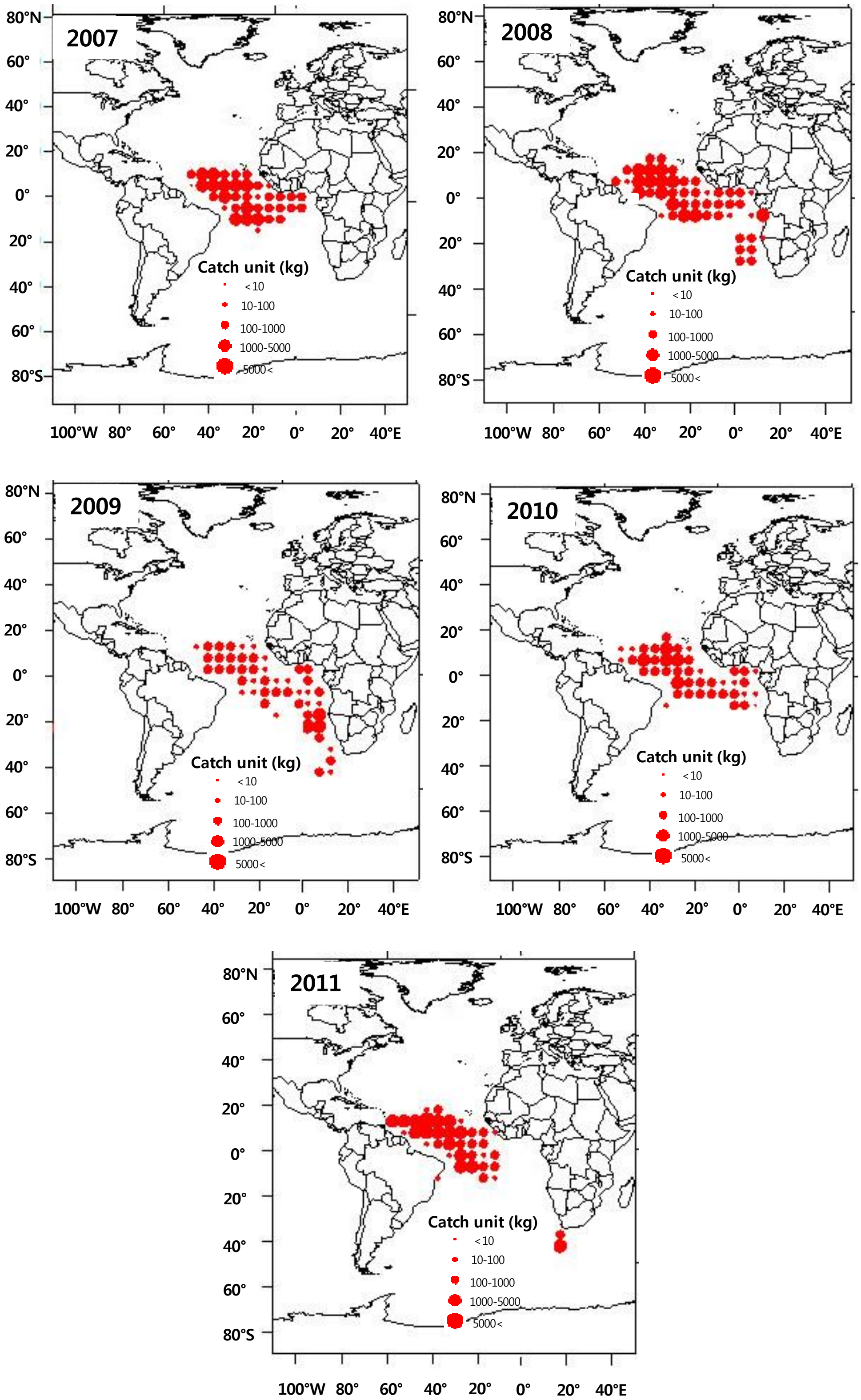

Figure 3. The spatial distributions of catch for Korean tuna longline fishery in the Atlantic Ocean for 5 recent years (2007-2011).

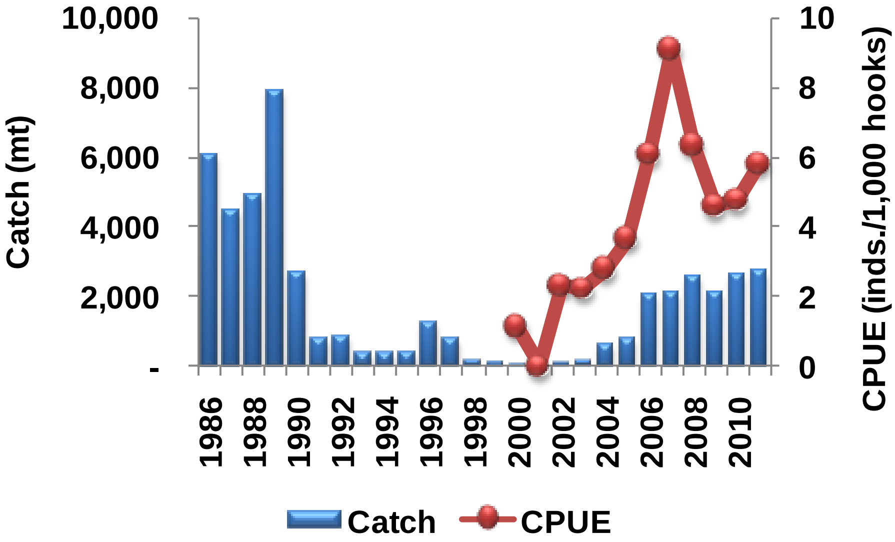

Figure 4. Variations in catches and CPUE of bigeye tuna caught by Korean tuna longline fishery in the Atlantic Ocean from 1986 to 2011.

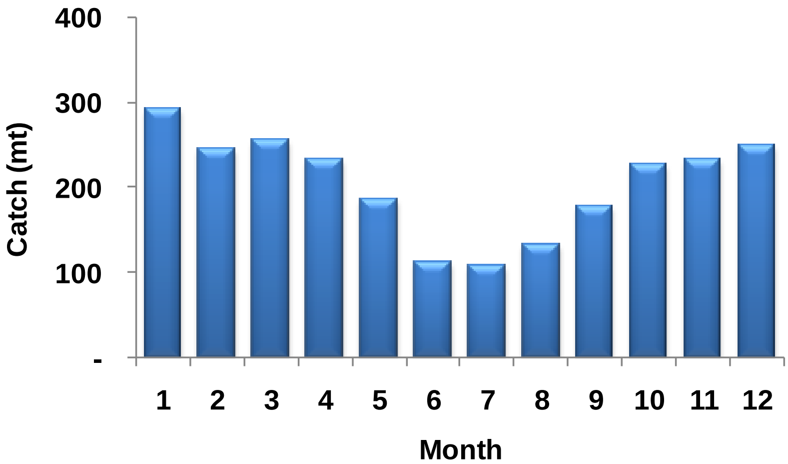

Figure 5. Monthly average catches of bigeye tuna caught by Korean tuna longline fishery in the Atlantic Ocean from 2007 to 2011.

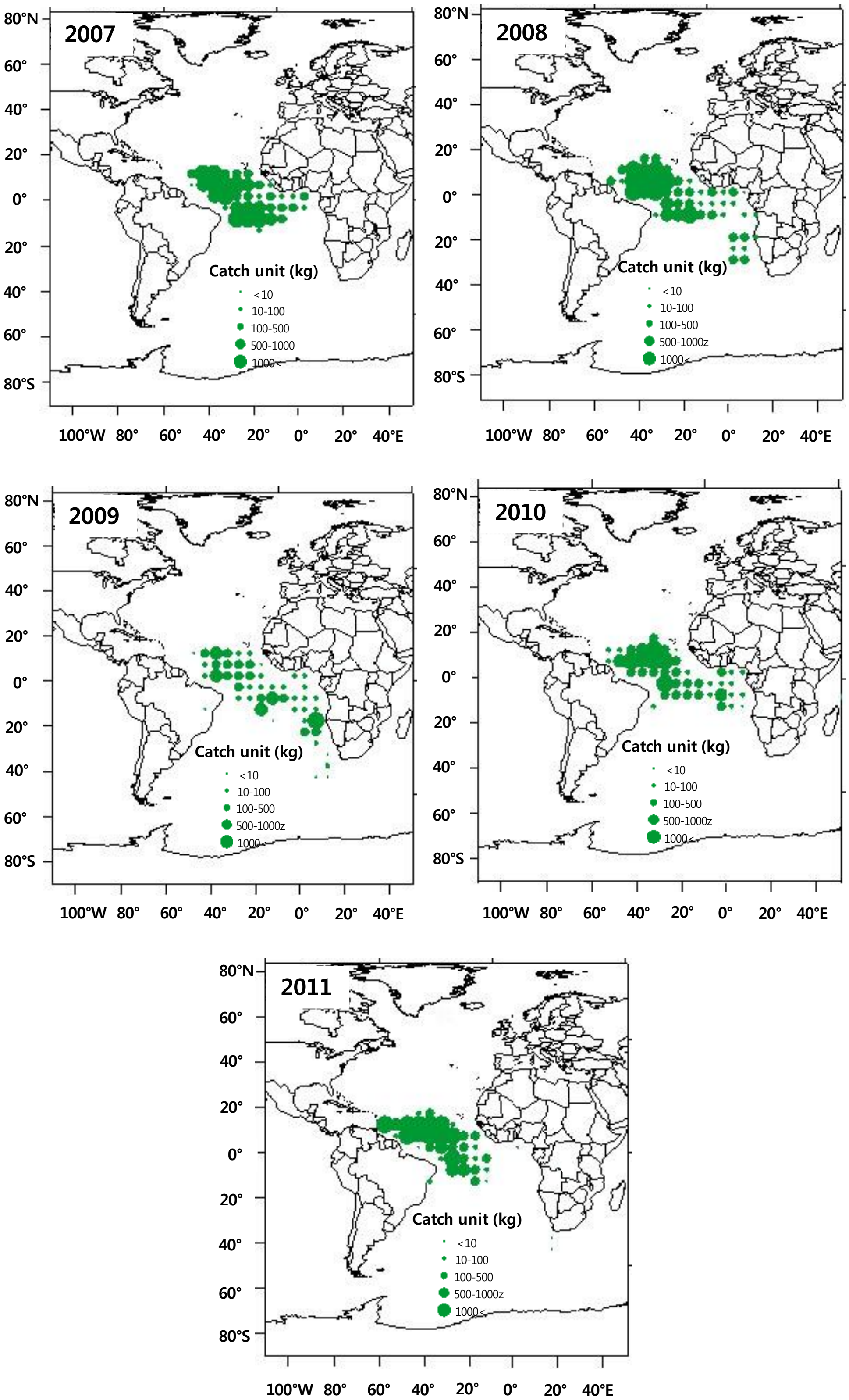

Figure 6. The spatial distributions of catch for bigeye tuna caught by Korean tuna longline fishery in the Atlantic Ocean for 5 recent years (2007-2011).

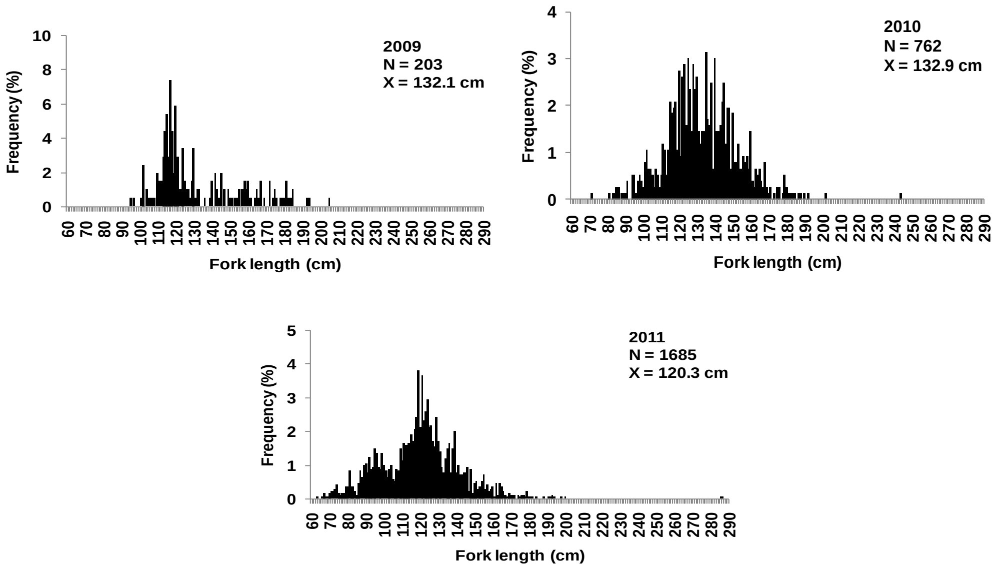

Figure 7. The length distribution of bigeye tuna caught by Korean tuna longline fishery in the Atlantic Ocean from 2009 to 2011.

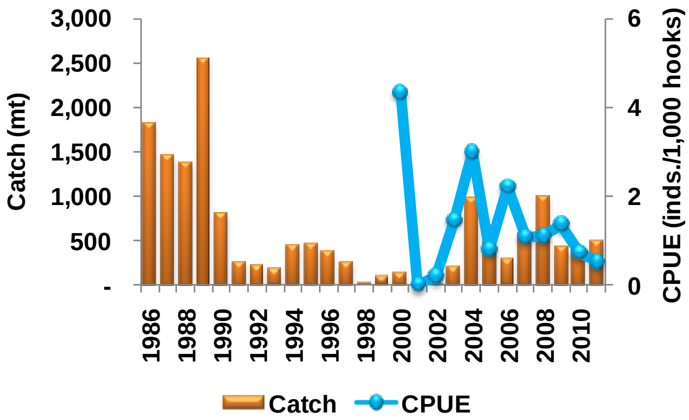

Figure 8. Variations in catches and CPUE of yellowfin tuna caught by Korean tuna longline fishery in the Atlantic Ocean from 1986 to 2011.

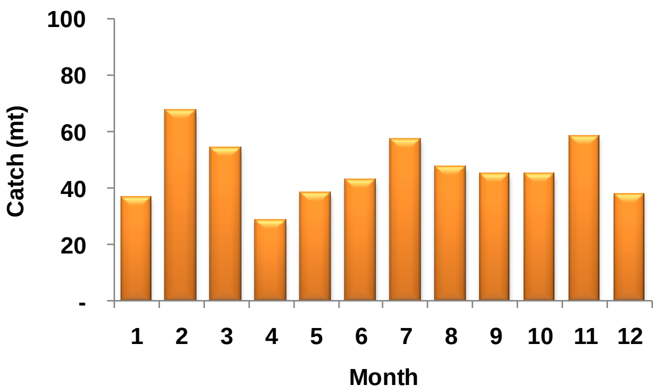

Figure 9. Monthly average catches of yellowfin tuna caught by Korean tuna longline fishery in the Atlantic Ocean from 2007 to 2011.

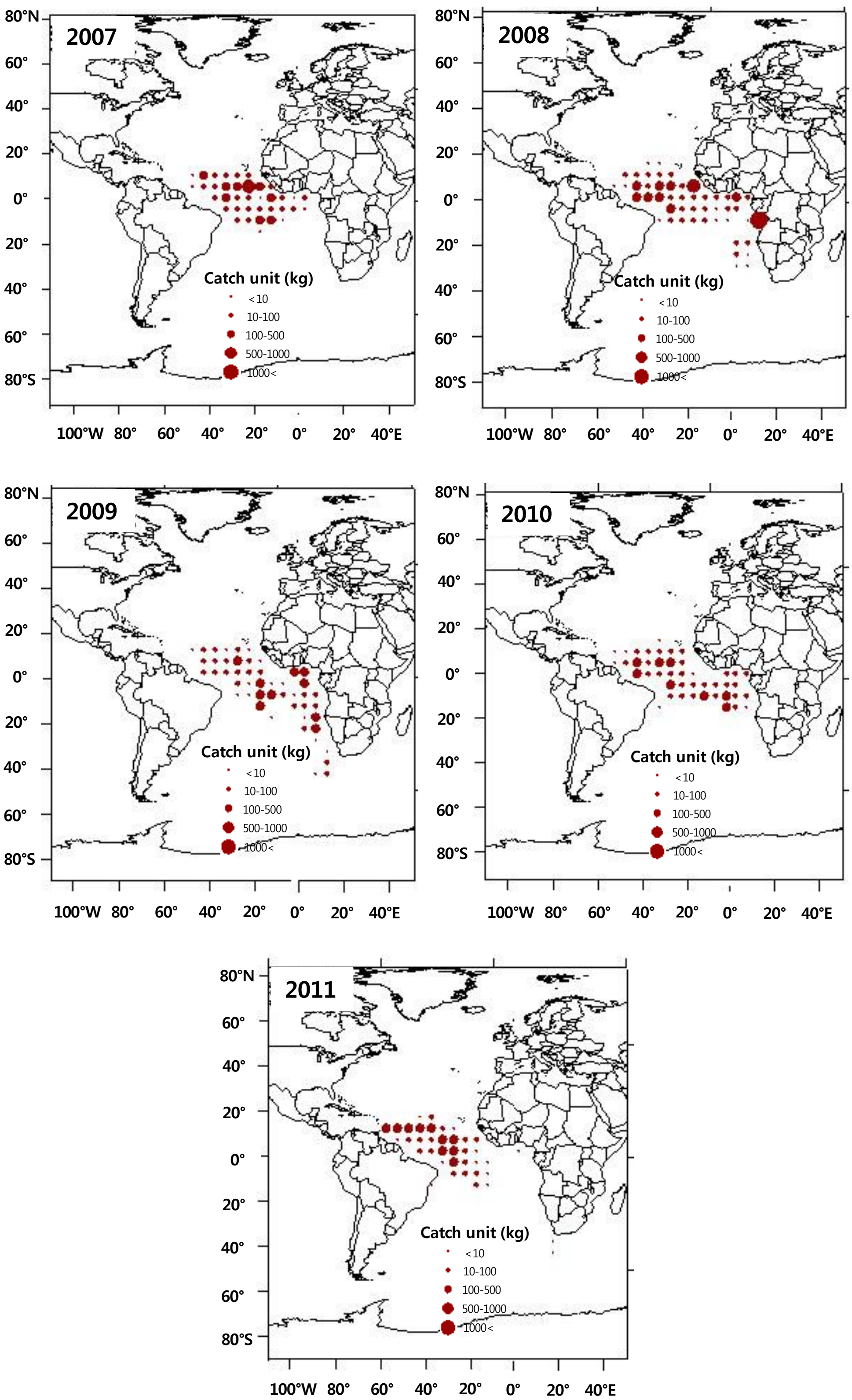

Figure 10. The spatial distributions of catch for yellowfin tuna caught by Korean tuna longline fishery in the Atlantic Ocean for 5 recent years (2007-2011).

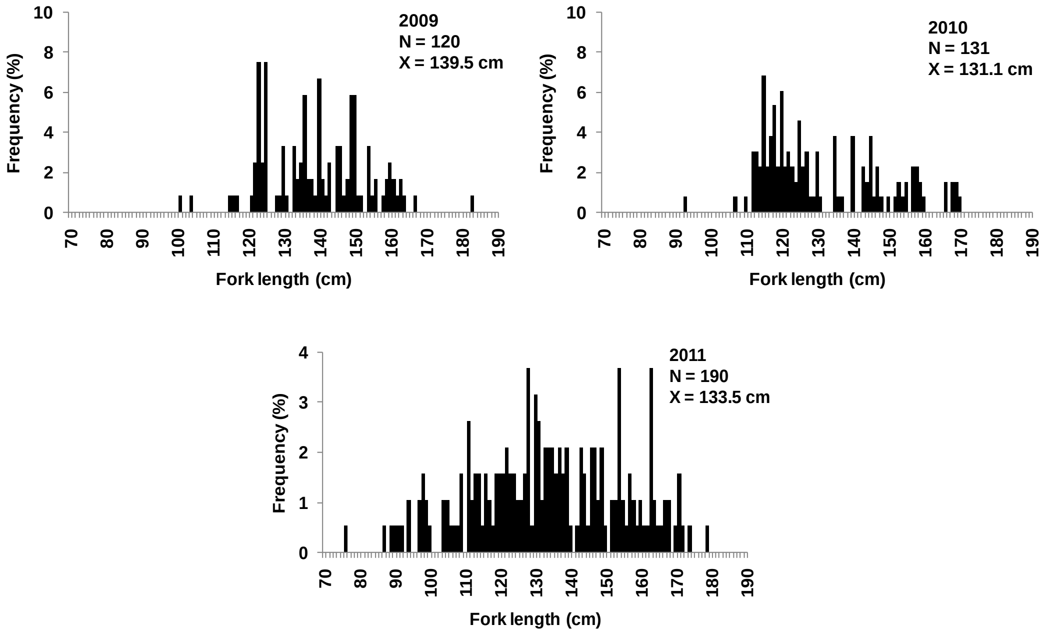

Figure 11. The length distribution of yellowfin tuna caught by Korean tuna longline fishery in the Atlantic Ocean from 2009 to 2011.

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EU/SPAIN FISH AGGREGATING DEVICE MANAGEMENT PLAN.

Alicia Delgado de Molina[1], Javier Ariz[1], J. Carlos Santana[1] and Silvia Rodriguez[1]

SUMMARY

This document analyzes the Fish Aggregating Device National Management Plan undertaken by the Spanish General Secretariat of Maritime Fisheries (Ministry of the Environment, Marine and Rural Affairs), in collaboration with the Spanish Institute of Oceanography (Ministry of Economy and Competitiveness), which will be compulsory for the Spanish freezer purse-seine fleet targeting tropical tuna (yellowfin-YFT, skipjack-SKJ and bigeye-BET) in the Atlantic, Indian and Pacific oceans.

RÉSUMÉ

Le présent document analyse le Plan national de gestion des dispositifs de concentration des poissons qu'a lancé le Secrétariat général de pêche de l'Espagne (Ministère de l'Agriculture, Alimentation et Environnement) en collaboration avec l'Institut espagnol d'océanographie (Ministère de l'Economie et de la compétitivité) afin que son application soit obligatoire dans la flottille espagnole de senneurs thoniers congélateurs qui ciblent les thonidés tropicaux (albacore, listao, thon obèse) dans les océans Atlantique, Indien et Pacifique.

RESUMEN

En el presente documento se analiza el Plan Nacional de Gestión de Dispositivos Agregadores de Peces que ha emprendido la Secretaría General de Pesca de España (Ministerio de Agricultura, Alimentación y Medio Ambiente), en colaboración con el Instituto Español de Oceanografía (Ministerio de Economía y Competitividad), para que sea de obligado cumplimiento en la flota española de atuneros cerqueros congeladores que tienen como especies objetivo a los túnidos tropicales (rabil-YFT, listado-SKJ y patudo-BET) en los océanos Atlántico, Indico y Pacífico.

KEYWORDS

Atlantic Ocean, tropical tuna, purse seine, catches, fishing effort,
artificial floating objects, bycatch species, sizes, catch-per-unit-of-fishing-effort

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1 Introduction

The tuna fishery over floating objects and marine animals, whether dead or decomposing, has been practised since the introduction of tropical tuna purse-seine fisheries in the three oceans where this type of fishery takes place.

In the early 1990s, the various purse-seine fleets began intentionally introducing floating artificial objects with buoys for the purpose of increasing tropical tuna catches, while making the fishing effort 'more effective' at the same time. Currently, around 50% of sets made by these fleets on a worldwide scale are undertaken using this fishing mode; the rest are made over free schools and, in the Eastern Pacific Ocean alone, over dolphins. This development has been similar in all three oceans. In the Atlantic, purse-seine catches are made over floating objects and free schools to an equal extent.

The tuna fishery over floating objects results in characteristic catches—yellowfin, skipjack and bigeye—generally of juvenile specimens in mixed shoals. The dynamics of association and behaviour of tuna over floating objects is one of the lines of research currently being followed by several research bodies, for the purpose of rendering this type of fishery more selective. Specimens from several taxonomic groups (osteichthyan and chondrichthyan fish, and turtles) are also caught alongside the target species in greater proportion overall than in catches over free schools, although both fishing modes bring in bycatch species, which, in some cases, are specific or virtually specific to the type of association.

More than 20 years of this fishery have resulted in a wealth of biological and other information needed to assess these resources. However, the information required for assessment is insufficient and inconclusive because of numerous methodological problems involving the data obtained from the assessment models, in particular the data derived from the use of abundance indices (catch per species, fishing effort and catch-per-unit-of-fishing-effort (CPUE)).

Several tuna regional fisheries management organizations (RFMO) have laid down resolutions whereby all parties are required to establish fish aggregating device (FAD) management plans, which must gather specific information, as is the case of the Commission for the Conservation of Atlantic Tuna (ICCAT), with a compulsory (number of FADs per vessel, characteristics and identifiers of the different FADs) and an optional component (catches made over FADs, efforts to mitigate bycatch, institutional agreements, etc.).

Irrespective of the fact that the National FAD Management Plan can be put to future use by the European Union and Spanish fishing authorities as a tool to govern this type of fishery, it goes much further in that it tends to provide qualitative and quantitative information about species associated (and caught) with FADs throughout the lifetime of the device. The plan also attempts to pinpoint key elements to identify the characteristics of FADs that yield specific captures and whether such captures are the result of the trajectory of the object through various zones (season, area) or a mixture of both factors (specific characteristics of FADs, or zone and season during which catches were made).

2 FAD Management Plan for the Spanish tropical purse-seine fleet

In 2011, the Spanish fisheries management organization laid down a Fish Aggregating Device Management Plan for the national fleet, which has been implemented to date.

Background

The prevailing fisheries regulations include several requirements that justify the implementation of a national FAD management plan for the tropical tuna fleet, such as the United Nations agreement on the conservation of fish stocks, the FAO code of conduct for responsible fisheries and Council Regulation (EC) No. 2371 on the conservation and sustainable exploitation of fisheries resources, etc.

Moreover, the four RFMOs to which the tropical fleets belong have adopted several requirements that oblige the different administrations to follow up FADs.

One of the plan's general aims is to establish a series of regulations that will facilitate compliance of the UN doctrine on the marking of fishing gear (including FADs), and prevent and avoid residue and waste being dumped at sea.

Specific objectives:

- To produce a register of floating objects and their characteristics,
- To improve information collection,
- To improve knowledge of FAD catch composition,
- To further knowledge of FADs and their impact on the ecosystem,
- To establish mechanisms for information exchange between scientists and administrations.

Justification of objectives:

The application of such a plan by all members that practise fisheries over floating objects will provide the RFMO managing these resources with important information about the following:

- Number and characteristics of the deployed objects that are picked up and remain in the fishery,
- Catches made (bycatch species) over each object and their characteristics (per area, composition by species),
- Possibility of the individualized follow-up of each object: lifetime, trajectory followed, catches made (target and bycatch species, sizes, etc.) throughout the lifetime of the object.

Scope

The regulations are binding for the entire tuna purse-seine fleet and its supply boats operating in all three oceans and flying the Spanish flag.

Information collection

The first two years (2011 and 2012) of the plan involved adapting formats to information collection. Accordingly, **Tables 1** and **2** show the forms used when the plan was launched. During this initial period, the vessels sent information in a variety of formats, using multiple names for the same material or for a similar event. In many cases, the information was sent in text files. That is, information that was very difficult to process would be gathered but often went unused. However, this first trial served to define the numerous types and variations of objects and the different activities carried out over them.

In 2013, a new format for information collection was introduced. **Table 3** shows the new information collection format for FAD inventory. All information pertaining to the type, shape and material of the object and type of buoy is included in this format. Each object is marked so that it can be followed up throughout its lifetime. The format is an Excel sheet containing several drop-down tables in the fields that require defining or specifying. **Table 4** provides an example of one of these drop-down sections and **Table 5** lists all the drop-down tables in the inventory form.

Table 6 shows the new format for gathering information about activity over FADs, which has come into use in 2013. This form contains an identification field for the FAD in order to connect it to the inventory form. Other fields are provided for buoy identification, information about the activity over the object (fishery, visit, loss, change of buoy, etc.), date and time, position and (in the event of a set) estimated total of tuna and bycatch. **Tables 7** and **8** also show an Excel sheet, containing explanatory comments and drop-down sections.

Table 1. Information collection format for FAD inventory (used in 2011 and 2012).

IDENTIFICATION		
DESCRIPTION OF THE FAD		
DIMENSIONS	WIDTH	
	LENGTH	
	DEPTH	
NET	DIMENSIONS	
	MATERIAL	
	MESH SIZE	
	OTHERS	
MATERIAL		
NUMBER OF ASSOCIATED BUOY		

Table 2. Information collection format for activity over FADs (used in 2011 and 2012).

C REGISTER OF SPECIFIC FAD ACTIVITY

Vessel: ________ **Code:** ________ **Registration No.:** ________ ________

Identification	Date	Time	Activity	Position	Observations

Table 3. New information collection format for FAD inventory (introduced in 2013).

ANEX I: Inventory															
Vessel				Registration											
FAD					FAD Dimensions			Rabo/Tail					Identification associated buoy	Type of associated buoy	Withdrawal or loss of FAD
Identification	Description	Material			width (m)	length (m)	height (cm)	depth (m)	material			mesh (mm)			

Table 4. Example of drop-down sections in the new information collection format for FAD inventory.

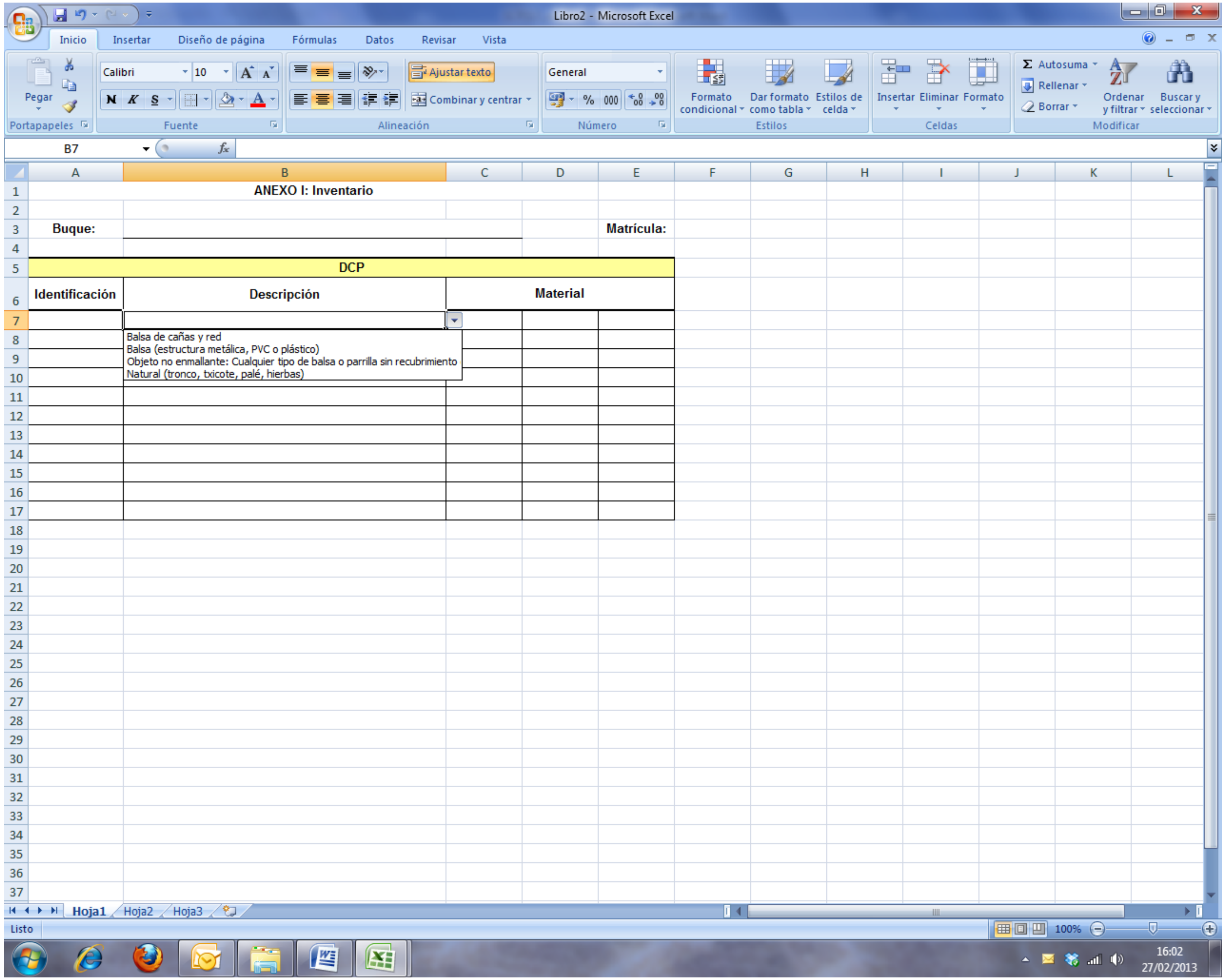

Table 5. Drop-down tables in the FAD inventory form.

Drop-down tables ANNEX I (Inventory):

Description
Raft of nets and reeds
Raft (metal, PVC or plastic structure)
Object with no mesh: Any kind of raft or rack with no covering
Natural (tree trunk, rope, pallet, grasses)

Type of buoy	FAD materials	Net or rabo/tail materials
GPS type SHERPE (ball)	Bamboo	Nylon
Satellite + echo sounder	PVC / Plastic	Piece of netting
Satellite without echo sounder/sonar	Metal	Tail-like
Satellite + sonar	Floats, corks, buoys, containers ...	Mesh material
	Piece of netting	Ropes
	Anti-fouling netting	Palm leaves

Table 6. New information collection format for activity over FADs (introduced in 2013).

ACTIVITY REGISTER

Vessel: ______________________ **Registration:** ______

Date	Time	FAD identification	Buoy identification	Activity	Position		Estimation of school (ton)	Estimation of accidental bycatch				Observations
					Lat	Long		Group	In no. specimens or weight (t)	No./W	No. specimens released alive	
D/M/Y	H/Min				Degree/Min	Degree/Min						

Table 7. Explanatory comments inserted in the activity register.

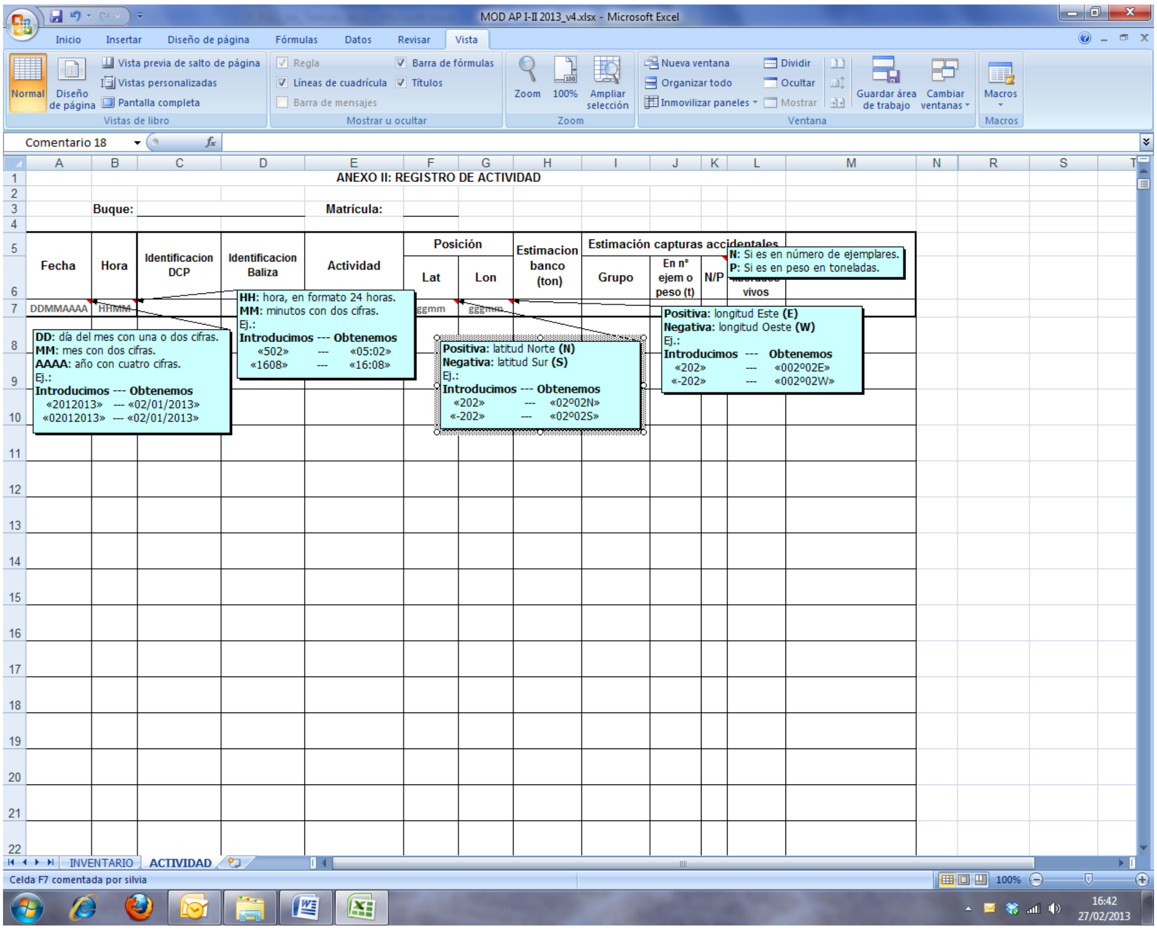

Table 8. Drop-down tables in the FAD activity form.

Groups	Activity	Bycatch
Turtles	Deployment	No.
Billfish, marlins	Verification	W
Swordfish	Set	
Frigate tuna	Collection	
Atlantic little tuna	Change of buoy	
Whale shark	Natural floating object	
Marine mammals	Loss	
	Recovered in port	

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STRENGTHENING GHANAIAN INDUSTRIAL PURSE SEINE FISHERY MONITORING IN THE GULF OF GUINEA

Emmanuel Chassot[1], Sylvia Ayivi[2], Laurent Floch[3], Laurent Dubroca[3], Pascal Cauquil[3], Alain Damiano[3]

SUMMARY

A 5-day workshop was held in Sète, France during May 27-31st 2013 between MFRD and IRD to improve the quality of Ghanaian fisheries data and define the methodological steps aimed at processing the time-series of data available for 2006-2012. The workshop was first dedicated to solving some technical problems in installing the AVDTH software and understanding some error messages generated by the tool AKADO used for checking and controlling data quality and consistency. In a second step, some specificity of the Ghanaian fisheries with regards to collaboration between purse seiners and baitboats and the availability of well plans were considered. The AVDTH referential of 'operations' was extended to include some particular activities linked to the transfer of fish from purse seiners to baitboats at-sea and a protocol of data entry was established. Finally, a full aggregated database for 2008-2011 was developed and converted into AVDTH v3.3. format after making vessel codes consistent with the IRD referential. Preliminary SQL and R codes which are available in appendix were developed to describe the fishing activities through several indicators such as the number of active vessels, the total annual catch, and total annual landings. Next steps will aim at extending the aggregated database to fully cover 2006-2012 and processing the data so as to provide Tasks 1 and 2 to the ICCAT.

RÉSUMÉ

Un atelier de cinq jours a été tenu à Sète (France) du 27 au 31 mai 2013, à l'initiative conjointe du MRFD et de l'IRD, dans le but d'améliorer la qualité des données halieutiques ghanéennes et de définir des approches méthodologiques destinées à traiter les séries temporelles de données disponibles pour la période 2006-2012. L'atelier s'est tout d'abord penché sur la résolution de quelques problèmes techniques dans l'installation du logiciel AVDTH et sur le déchiffrage de quelques messages d'erreur générés par l'outil AKADO dans le cadre de la vérification et du contrôle de la qualité et de la cohérence des données. Dans un second temps, les scientifiques examineront certaines caractéristiques spécifiques aux pêcheries ghanéennes en ce qui concerne la collaboration entre les senneurs et les canneurs et la disponibilité des plans. Le référentiel AVDTH de "opérations" a été étendu pour inclure quelques activités particulières liées au transfert en mer des poissons des senneurs aux canneurs et un protocole de saisie des données a été établi. Finalement, une base de données complètement agrégée pour 2008-2011 a été développée et convertie en version AVDTH format 3.3, une fois que les codes navires ont été rendus compatibles avec le référentiel de l'IRD. Les codes préliminaires SQL et R qui sont disponibles en appendice ont été développés afin de décrire les activités de pêche par le biais de plusieurs indicateurs, tels que le nombre de navires actifs, la prise annuelle totale et le total des débarquements annuels. La prochaine étape visera à étendre la base de données agrégées afin qu'elle englobe complètement la période 2006-2012 et à traiter les données dans le but de fournir à l'ICCAT les Tâches I et II.

RESUMEN

Se celebraron en Sète, Francia, unas Jornadas de trabajo de cinco días, del 27 al 31 de mayo de 2013, entre el MFRD y el IRD, para mejorar la calidad de los datos de las pesquerías de Ghana y definir los pasos metodológicos para procesar las series temporales de datos

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disponibles para 2006-2012. En un primer momento las jornadas se centraron en resolver algunos problemas técnicos en la instalación del programa AVDTH y descifrar algunos mensajes de error generados por la herramienta AKADO, utilizada para comprobar y controlar la coherencia y la calidad de los datos. En una segunda fase, se consideraron algunas especificidades de las pesquerías ghanesas en lo que concierne a la colaboración entre cerqueros y barcos de cebo vivo y la disponibilidad de los planos de cubas. El referencial AVDTH de "operaciones" se amplió para incluir algunas actividades vinculadas con la transferencia de peces desde los cerqueros hasta los barcos de cebo vivo en el mar y se estableció un protocolo para la introducción de datos. Finalmente, se desarrolló una base de datos totalmente agregada para 2008-2011 y se convirtió al formato AVDTH versión 3.3 tras hacer que los códigos de los buques fueran coherentes con el referencial del IRD. Se desarrollaron de forma preliminar los códigos R y SQL, que están disponibles en apéndice, para describir las actividades de pesca mediante varios indicadores como el número de buques activos, la captura anual total y los desembarques anuales totales. Las siguientes fases tendrían como objetivo ampliar las bases de datos agregadas para cubrir totalmente el periodo 2006-2012 y procesar los datos para proporcionar la Tarea I y la Tarea II a ICCAT.

KEYWORDS

Catch statistics, High seas fisheries, Purse seining,

1. Introduction

A workshop was held between IRD and MFRD from the 27th to the 31st of May 2013 within the framework of the action 4 of the project “Strengthening Ghanaian industrial purse seine fishery monitoring in the Gulf of Guinea”. The main objectives of the workshop were (i) to assess the quality of the datasets available for processing the baitboat (BB) and purse seine (PS) fishery data over the period 2006-2012, (ii) to define specific modifications of softwares (AVDTH, AKADO, T3 +) adapted to the Ghanaian fishery and its sampling procedures.

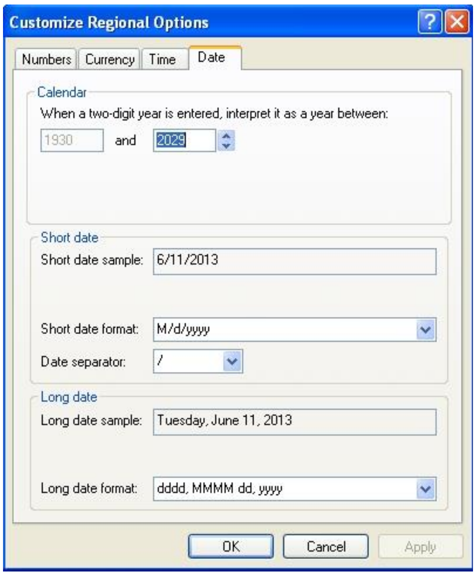
2. Some technical aspects

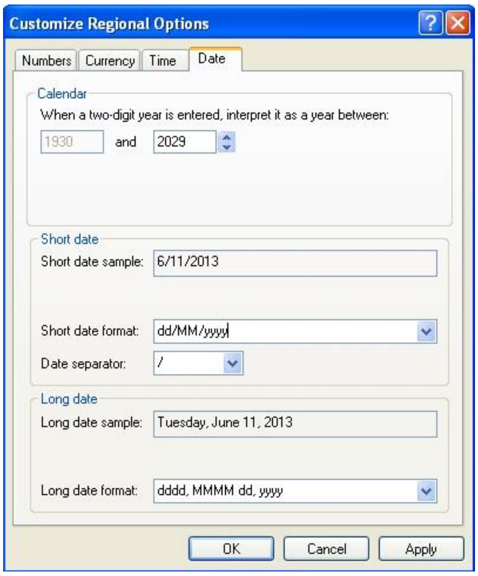
2.1 AVDTH v3.3 installation and date formats

A technical solution was provided to MFRD for installing the most recent version of AVDTH (v3.3) on Windows 7. In addition, a problem was detected with date format on operating system of Sylvia Ayivi's computer. The following process was used to declare the date format when using AVDTH and other softwares of the "Observatoire Thonier" on Windows operating system:

-> Start -> All Programs -> Control Panel -> Date, Time, Language, and Regional Options -> Change the format of numbers, dates, and times -> Customize -> Date

Modify short date format M/d/yyyy by -> dd/MM/yyyy following:





2.2 TunaLetter

An introduction to the TunaLetter which consists of a suite of SQL queries implemented in a MS ACCESS database that can be linked to any AVDTH database was made. Queries enable to extract several indicators and statistics such as annual landings by gear, list of active vessels, etc.

2.3. AKADO software

Based on the example of the 2006 AVDTH database, MFRD provided IRD with a list of the different errors (screen prints) arising when running the AKADO software associated with their interpretation of the errors (**Appendix 1**). For each error message, IRD will write a proper "log" message explaining the error cause in order to help the user to make appropriate corrections to the data when needed. Message errors in French will be included in the AKADO manual that will be improved and provided to the ICCAT secretariat for English translation.

3 Some precisions in Ghanaian fisheries data

3.1. Collaboration between purse seiners and baitboats

Collaboration between Ghanaian PS and BB occurs when a baitboat asks for the assistance of a purse seiner to catch a tuna school. Recently, about 80% of BB operations on drifting fish aggregating devices (FADs) would involve collaboration with a PS. The PS catch is shared between both vessels, generally equally (i.e. 50%), but the portion of catch transferred at-sea to the BB can reach 100% in some cases. The information on collaboration (i.e. name of the vessel and magnitude of catch shared) is generally present in the logbooks but it has not been recorded until now in AVDTH because of missing dedicated fields for data entry. When the transfer of fish is 100% of the catch, the information is generally not recorded in the logbook of the PS, which can result in an underestimation of the number of sets and catch. Also, even if the baitboat started to fish on the school before the arrival of the purse seiner, the information on this initial activity and associated catch is generally not recorded in the logbook in which only the collaborative activity is present.

CASE 1. The BB started to fish on the FAD and recorded the information before collaboration started.

- <u>Two activities</u> for BB must be entered into AVDTH: (1) the positive catch [C_OPERA = 1 AND C_ASSOC = 20-24 AND C_TBANC = 1], (2) the transfer of fish from the purse seiner to the baitboat [C_OPERA = 12[4] AND C_ASSOC = 100[5] AND C_TBANC = 1]

[4] Fish transfer from a purse seiner
[5] Collaboration with purse seiner for sharing the catch

CASE 2. No information on catch of the BB is recorded before the collaboration started. We assume that the "potential" initial catch of the baitboat was negligible:

- One activity for BB must be entered into AVDTH: the transfer of fish from the purse seiner to the baitboat [C_OPERA = 12[6] AND C_ASSOC = 100[7] AND C_TBANC = 1]

- Two activities for PS must be entered into AVDTH: (1) the positive catch [C_OPERA = 1 AND C_ASSOC = 20-24]. The catch recorded in ACTIVITE.V_POIDS_CAP would only correspond to the catch retained by the purse seiner, (2) the transfer of part of the PS catch to the baitboat [C_OPERA = 19[8] AND C_ASSOC = 98[9] AND C_TBANC = 1). The catch transferred from the PS to the BB would be indicated in the fields V_POIDS_CAPT of the table CAPT_ELEM.

Note that the coding is generic so that collaboration between PS and BB on free-swimming schools would follow the same scheme (C_TBANC=2 or 3). It was proposed that information on the collaborative vessels (i.e. codes of PS or BB) available from the logbooks could be entered as a comment in AVDTH. This information might reveal useful for future analyses.

3. 2. Well maps and information on the sets

Although the well maps, i.e. plans that describe where the catch of the fishing sets is stored, have become recently available for most Ghanaian PS, discussions with fishermen crews indicated that some shifting (i.e. fish transfer between wells) occurs at-sea to ensure vessel equilibrium. This results in the loss of information on the catch (i.e. time, area, and fishing mode) when sampling a well. Some Ghanaian PS (i.e. TTV Company) might not perform such shifting practices and MFRD will identify in a near future the vessels for which well maps accurately reflect the origin of the fishing sets.

For size-samples conducted on BB, the whole vessel is considered as 1 unique well and information on the catch (i.e. time, area, and fishing mode) is derived from all fishing activities reported in the logbook. The species and size composition might however be a mix of PS and BB catch in the case of transfer of catch at-sea (see Section 3.1). The distribution of catch per set for each fishing mode did exhibit several outliers with 4.4% of the sets with catch larger than 40 t corresponding to the 95% quantile value (**Figure 1**). Following MFRD, catches of Ghanaian BB during 1 operation could reach a maximum of 200 t. It appeared therefore not possible to identify the catches related to collaborations from the distribution of the BB catch.

4 Developing an aggregated AVDTH database for 2006-2012

A common vessel reference list was agreed between IRD and MFRD in 2011 and implemented in 2012. All vessel codes in the AVDTH databases available for the period 2008-2011 were corrected according to the new referential for consistency over time. The corrections concerned the tables trip (table MAREE), activities (table ACTIVITE), wells (table CUVE), and samples (table ECHANTILLON) and resulted in several changes in vessel codes and associated names. For instance, ACE1 and GBESE8 would become ACE1 in 2009, DELALI would be split between DELALI and LAURENT, etc. The databases were then merged and converted to the most recent version of AVDTH, i.e. v3.3.

In order to finalize a full Ghanaian fisheries database for 2006-2012, it was agreed that the following work would be conducted before July 2013:

- MFRD will make modifications in vessel codes for 2006 that could not be made during the WG due to a lack of information, and convert the 2006 database to v3.3,
- IRD will manage the entry of the fisheries data available for 2007 in MS Excel file,
- MFRD will finalize the 2012 database and convert it to v3.3.

[6] Fish transfer from a purse seiner
[7] Collaboration with purse seiner for sharing the catch
[8] Fish transfer toward a baitboat
[9] Collaboration with a baitboat for sharing the catch

5 Preliminary analyses of landing and logbook data for 2008-2011

5.1 Ghanaian task 1

The total yearly landings and catches in the 2008-2011 AVDTH database were compared with the data available in the current ICCAT database. **Table 1** indicates that the current ICCAT task 1 includes some inconsistencies: (i) the PS task 1 in 2008 and 2009 underestimates the AVDTH landings by about 90% and 11%, respectively, (ii) the BB task 1 in 2011 underestimates the AVDTH catches by 46%. These underestimates are certainly conservative as the AVDTH databases likely do not cover 100% of the Ghanaian fishing vessels activities.

It is noteworthy from **Table 1** that landings and catches for PS and BB in 2009 and for BB in 2010 were very similar while the catches for PS in 2010 and 2011 only represented 66% and 50% of the landings, respectively. This might indicate either an improvement in the collection of tuna sale records or on the other hand could reveal a decrease in the collection of logbook data, e.g. 41,000 t recorded in 2009 vs. 27,000 t in 2011.

5.2 Ghanaian active vessels

The corrections made with regards to vessel codes allowed to derive the numbers of active vessels from the 2008-2011 AVDTH database. **Table 2** shows that some Ghanaian purse seiners did not provide any logbook data to MRFD in 2010 and 2011 while their landings were monitored: PANOFI MASTER, PANOFI DISCOVERER, PANOFI PATHFINDER, PANOFI FORERUNNER, and PANOFI FRONTIER.

Conclusions

The workshop was a success for (i) understanding some specificity of the Ghanaian surface fisheries and sampling operations, (ii) improving the consistency in the Ghanaian fisheries datasets through correction of the vessel codes to create a reference database for the period 2006-2012, and (iii) starting exploring the Ghanaian data. The availability of a unique AVDTH database in v3.3 format from July 2013 will facilitate the following steps of the work to process the time series so as to correct for the species-specific composition of the catch and produce the ICCAT task 2 data. Special effort will be dedicated to provide the maximum of information about the analyses conducted through the description of all SQL queries and R codes used to extract and process the data.

Table 1. Comparison between the total catches for the Ghanaian fishing vessels ICCAT task 1 (May 2013) by year and gear group with landings and catches* as available in the 2008-2011 AVDTH database. Note that the year of landing does not exactly correspond to the year of catch due to overlap of some trips between 2 successive years. BB = baitboat; PS = purse seiner.

YearC	GearGrp	ICCAT	Landings	Catch
2008	BB	43932	25259	22330
2008	PS	20162	38624	18545
2009	BB	31126	27284	27809
2009	PS	35344	39405	40977
2010	BB	23885	21733	22035
2010	PS	56335	56132	36778
2011	BB	16410	16574	23918
2011	PS	53395	54005	26998

* SQL queries and R codes are given in appendix

Table 2. Number of distinct active vessels by year and gear group. A vessel was considered to be active if it was recorded at least once in the tables MAREE (fish sale records) or ACTIVITE (logbooks) of AVDTH. N_maree and N_activite indicate the numbers of active vessels from the tables MAREE ACTIVITE, respectively. BB = baitboat; PS = purse seiner

YearC	GearGrp	N_maree	N_activite
2008	BB	19	19
2008	PS	9	7
2009	BB	19	19
2009	PS	12	12
2010	BB	20	19
2010	PS	16	12
2011	BB	15	15
2011	PS	16	12

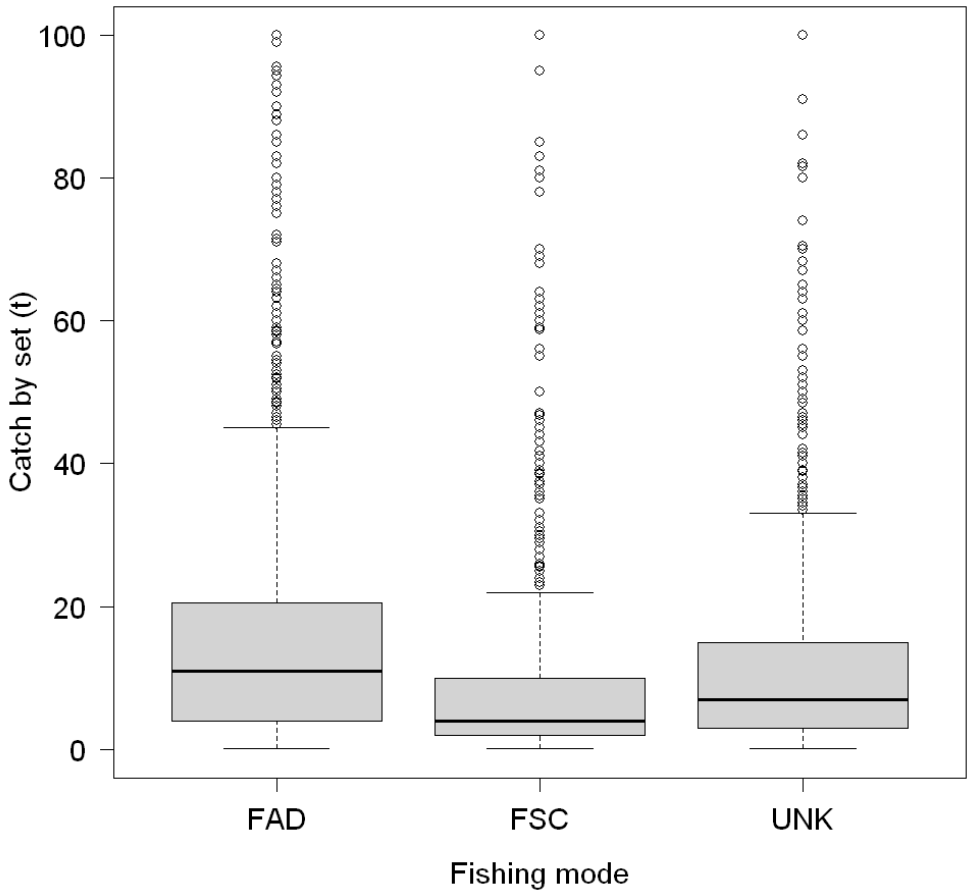


Figure 1. Distribution of the catch per set for the Ghanaian baitboats during 2008-2011. FAD = fish-aggregating device; FSC = free-swimming school; UNK = unknown fishing mode. Note that the y-axis was restricted to a maximum of 100 t but 54 of the 6,884 activities showed catch > 100 t.

Appendix 1. Case studies of AKADO errors with interpretation from MFRD and IRD

MAREES (Landing)

1. Example 1

A

Les marées 1/2 :

E/W	Marée			Jour départ				Jour arrivée			Distance		Séquence
-	C_BAT	Type	D_DBQ	D_DEPART	Act_J_deb	S_tm_d	S_tp_d	Act_J_fin	S_tm_f	S_tp_f	V_LOCH	S_Dist	-
E	365	BB	05-06-2006	12-05-2006	11-05-2006	24	12	05-06-2006	24	12	-	3223	-
E	365	BB	04-10-2006	31-08-2006	01-09-2006	24	12	04-10-2006	24	12	-	2333	-
E	365	BB	20-11-2006	18-10-2006	19-10-2006	24	12	20-11-2006	24	12	-	3294	-
E	366	BB	11-04-2006	23-02-2006	23-02-2006	24	12	10-04-2006	24	12	-	5833	-
E	366	BB	05-08-2006	16-07-2006	15-07-2006	24	12	04-08-2006	24	12	-	2326	-
E	366	BB	03-10-2006	05-09-2006	06-09-2006	24	12	03-10-2006	24	12	-	1808	-
E	366	BB	15-11-2006	12-10-2006	14-10-2006	24	12	12-11-2006	24	12	-	2566	-
E	368	BB	24-07-2006	18-06-2006	18-06-2006	24	12	24-07-2006	24	12	-	4355	rupture
E	373	BB	02-05-2006	03-04-2006	04-04-2006	24	12	02-05-2006	24	12	-	3003	-
E	373	BB	15-06-2006	10-05-2006	07-05-2006	24	12	15-06-2006	24	12	-	4037	rupture
E	373	BB	13-10-2006	18-09-2006	18-09-2006	24	12	12-10-2006	24	12	-	1180	-
E	373	BB	04-12-2006	20-10-2006	21-10-2006	24	12	04-12-2006	24	12	-	4562	-
E	375	BB	03-01-2006	19-11-2005	19-11-2005	12	0	03-01-2006	12	0	-	4185	rupture
E	383	BB	26-01-2006	24-12-2005	24-12-2005	12	0	07-01-2006	24	12	-	1698	-
E	383	BB	20-09-2006	16-08-2006	16-08-2006	24	12	19-09-2006	24	12	-	2635	-

C

B

A. Departure date in landing is different from departure date in Activity (logbook) for corresponding trip.
Logbook and landing forms should be checked to cross-check the data.

B. Arrival date in landing is different from Arrival date in Activity (logbook) corresponding trip.

Change departure date of landing to what is indicated in logbook

C. No total landing but logbook entered into Activity form
Modify F_CAL_VID (Partial landing) declaration and run again AKADO

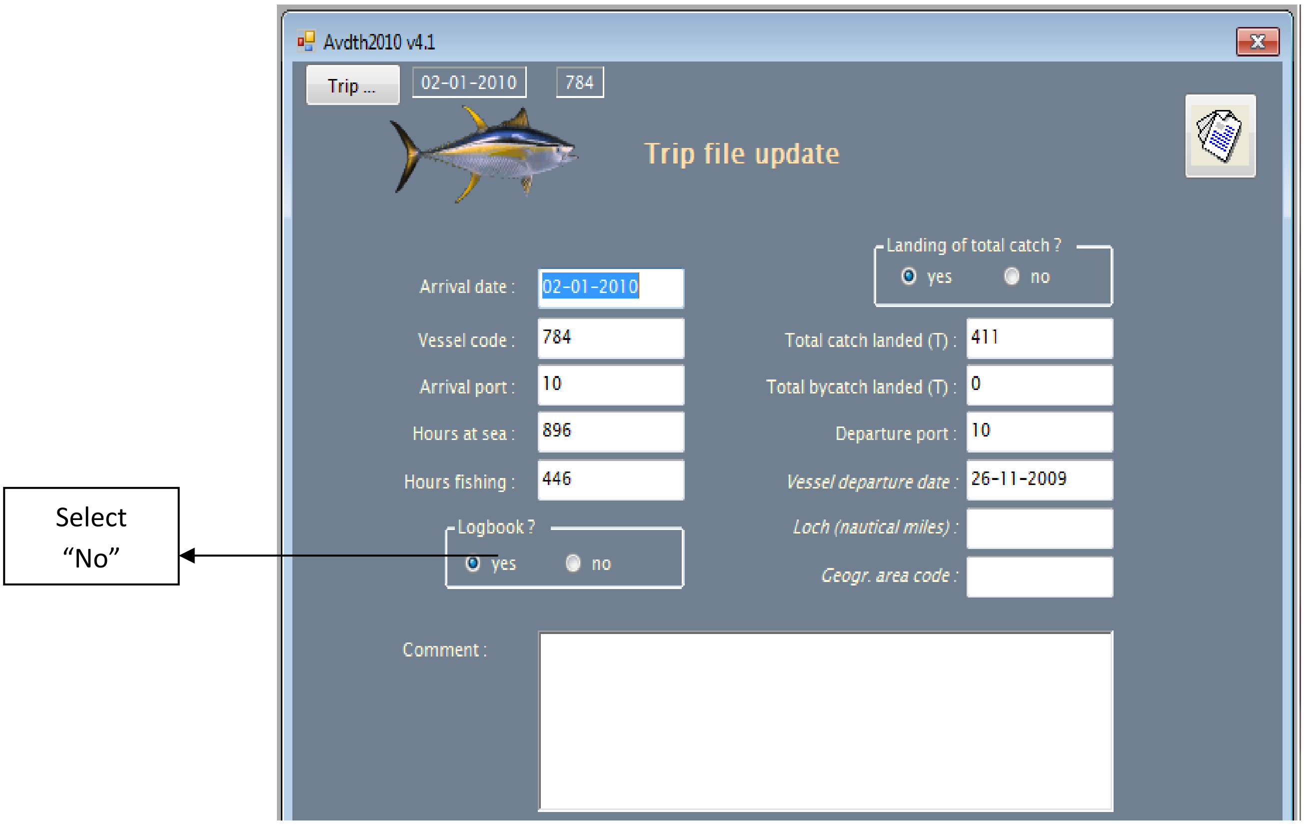
E	644	PS	11-08-2006	02-08-2006	02-08-2006	24	12	10-08-2006	24	12	-	421	-
E	644	PS	24-09-2006	11-09-2006	12-09-2006	24	12	24-09-2006	24	12	-	1857	-
E	694	PS	01-02-2006	17-12-2005	17-12-2005	24	12	01-02-2006	24	12	-	7912	rupture
E	718	PS	08-05-2006	22-03-2006	22-03-2006	24	12	08-05-2006	24	12	-	5225	rupture
E	749	BB	08-02-2006	16-01-2006	?	?	?	?	?	?	-	0	rupture
E	749	BB	12-09-2006	06-09-2006	?	?	?	?	?	?	-	0	rupture
E	761	BB	13-02-2006	02-12-2005	?	?	?	?	?	?	-	0	rupture
E	761	BB	24-10-2006	01-10-2006	01-10-2006	24	12	23-10-2006	24	12	-	1674	-

D

First step: Modify F_CAL_VID (Partial landing) declaration and run again AKADO.

D. No logbook entered

Select 'No logbook' button on the Landing dialogue box



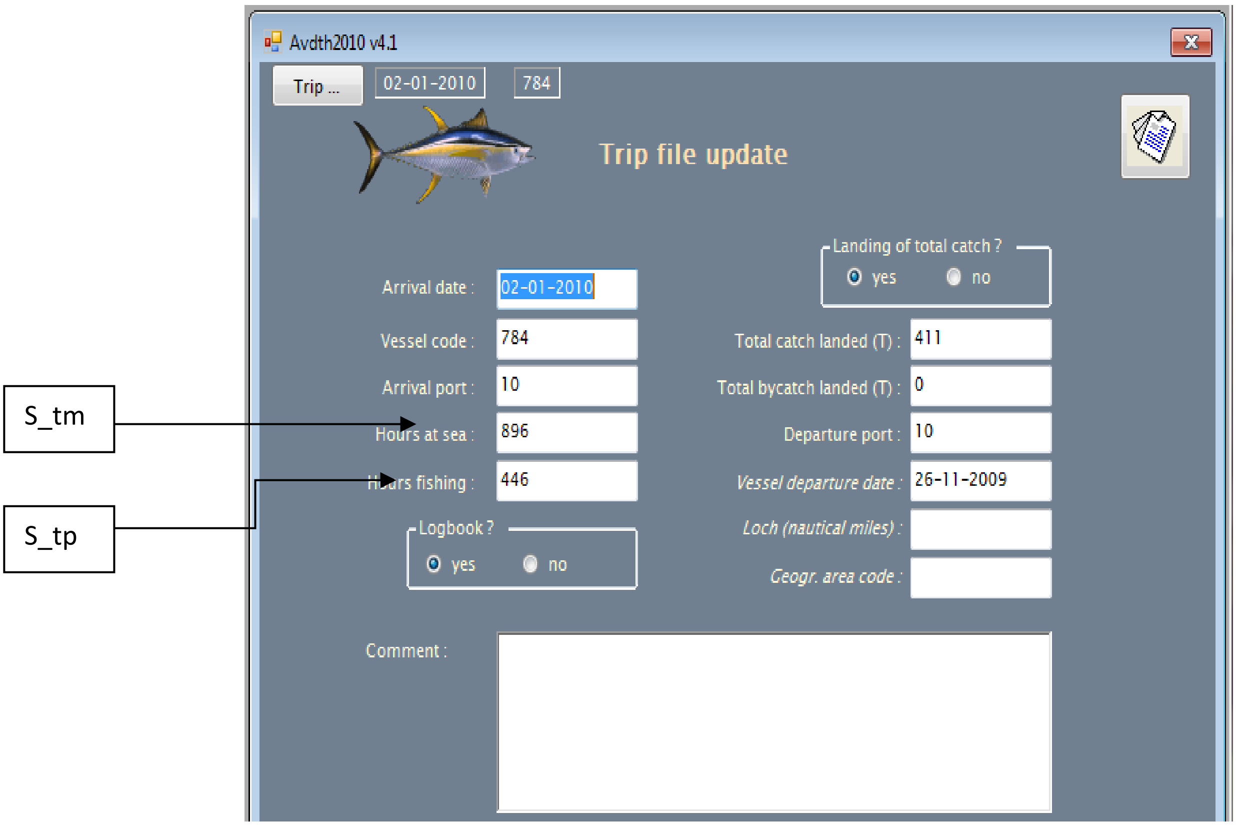
MAREE 2/2

E

Les marées 2/2 :

E/W	Marée			Temps Mer		Temps Pêche		Poids débarqué		Départ	Captures	R.	Enquête	Echantillon		
-	C_BAT	Type	D_DBQ	TM	S_tm	TP	S_tp	V_POIDS	S_P_Lots	F_CAL_VID	S_P_Capt	-	F_ENQ	N	S_Pond	S_Poids
E	365	BB	12-01-2006	0	792	0	384	199.8	199.8	1	214.5 | 214.5	0.93	1	1	35	199.8
E	365	BB	13-02-2006	600	600	276	300	285.4	285.4	1	307 | 307	0.93	1	1	50	285.4
E	365	BB	27-03-2006	0	888	0	432	300.1	300.1	1	288.5 | 288.5	1.07	1	1	30	300.1
E	365	BB	30-04-2006	648	672	264	336	200	200	1	195 | 195	1.03	1	1	30	200
E	365	BB	05-06-2006	552	624	252	312	300.4	300.4	1	325 | 325	0.92	1	1	47	300.4
E	365	BB	04-10-2006	792	816	300	408	295.6	295.6	1	331 | 331	0.89	1	1	70	295.6
E	365	BB	20-11-2006	768	792	360	396	250	250	1	250 | 250	1	1	1	47	250
E	366	BB	14-02-2006	936	984	432	492	275.5	275.5	1	234.2 | 234.2	1.18	1	1	33.3	275.5
E	366	BB	11-04-2006	1104	1128	516	564	180.4	180.3	1	333.9 | 333.9	0.88	1	1	54.5	180.4
E	366	BB	24-05-2006	768	?	336	?	220.4	220.5	1	- | -	0	0	1	-	220.4
E	366	BB	07-07-2006	864	888	396	444	211.5	211.5	1	194.3 | 194.3	1.09	1	1	41.6	211.2
E	366	BB	05-08-2006	480	504	192	252	150.4	150.4	1	137 | 137	1.1	1	1	42.8	150.4

E. Input the values from the columns S_tm and S_tp into the fields Hours at Sea and Hours Fishing respectively.
Usually, when entering the Trip file update you need not entering hours at sea and fishing hours. After having entered the whole activities for one trip, just run Akado: it will calculate the sum of hours at sea (S_tm) and fishing hours (S_tp) entered for each day of activity and just report them into the adequate fields.



Activity (Logbook)

2.

Les activités :

E/W	Activité					Opération	Poids			Associations		Position						T °C
-	BAT	Type	D_DBQ	D_ACT	N_ACT	OPERA	POIDS_CAP	S_capt_elem	S_pond_act	TBANC	Assoc	Q	LAT	LON	A terre	OA/OI	N_Ech	-
E	365	BB	12-01-2006	06-01-2006	1	1	35	35 | 35	-	3	-	3	4	1404	non	1	4	-
E	365	BB	27-03-2006	23-03-2006	1	1	30	30 | 30	-	3	-	2	312	328	non	1	27	-
E	365	BB	30-04-2006	19-04-2006	1	1	30	30 | 30	-	3	-	2	257	415	non	1	11	-
E	365	BB	05-06-2006	17-05-2006	1	1	47	47 | 47	-	3	-	3	430	259	non	1	8	-
E	365	BB	04-10-2006	24-09-2006	1	1	70	70 | 70	-	3	-	1	328	227	non	1	6	-
E	365	BB	20-11-2006	14-11-2006	1	1	47	47 | 47	-	3	-	2	157	846	non	1	8	-
E	366	BB	14-02-2006	08-02-2006	1	1	33.3	33.3 | 33.3	-	3	-	4	124	23	non	1	16	-
E	366	BB	11-04-2006	09-04-2006	1	1	54.5	54.5 | 54.5	-	3	-	4	32	233	non	1	4	-
E	366	BB	07-07-2006	14-06-2006	1	1	41.6	41.6 | 41.6	-	3	-	3	127	859	non	1	5	-
E	366	BB	05-08-2006	31-07-2006	1	1	42.8	42.8 | 42.8	-	3	-	3	159	801	non	1	3	-
E	366	BB	03-10-2006	29-09-2006	1	1	47.1	47.1 | 47.1	-	3	-	1	359	205	non	1	3	-
E	366	BB	15-11-2006	23-10-2006	1	1	1.7	1.7 | 1.7	-	3	-	4	536	24	oui	1	-	-
E	366	BB	15-11-2006	08-11-2006	1	1	85	85 | 85	-	3	-	4	411	651	non	1	4	-
E	368	BB	20-02-2006	14-02-2006	1	1	41.5	41.5 | 41.5	-	3	-	4	117	109	non	1	8	-
E	368	BB	22-04-2006	21-04-2006	1	1	24	24 | 24	-	3	-	4	405	43	non	1	5	-
E	368	BB	05-06-2006	11-05-2006	1	1	34	34 | 34	-	3	-	4	29	1222	non	1	9	-
E	368	BB	24-07-2006	12-07-2006	1	1	81	81 | 81	-	3	-	4	347	1506	non	1	7	-
E	368	BB	27-10-2006	15-10-2006	1	1	50	50 | 50	-	3	-	3	124	915	non	1	12	-
E	373	BB	15-02-2006	08-02-2006	1	1	60	60 | 60	-	3	-	1	535	119	non	1	13	-

On land

Error indicates the position of activity is on Land

Check and update the position of activity

3.

Associate code

E	564	BB	25-06-2006	29-05-2006	1	1	79.5	79.5 | 79.5	-	3	-	3	149	846	non	1	11	-
E	564	BB	16-08-2006	11-08-2006	1	1	65	65 | 65	-	3	-	3	313	700	non	1	8	-
E	564	BB	01-10-2006	27-08-2006	1	9	?	- | -	-	3	-	4	530	27	oui	1	-	-
E	564	BB	01-10-2006	28-08-2006	1	9	?	- | -	-	3	-	4	530	25	oui	1	-	-
E	564	BB	01-10-2006	26-09-2006	1	1	50	50 | 50	-	3	-	4	14	1501	non	1	7	-
E	564	BB	21-11-2006	13-11-2006	1	1	80.5	80.5 | 80.5	-	3	-	4	4	1315	non	1	5	-
E	577	BB	16-04-2006	11-04-2006	1	1	21.7	21.7 | 21.7	-	3	-	3	108	509	non	1	12	-
E	577	BB	24-07-2006	09-07-2006	1	1	12.2	12.2 | 12.2	-	2	21 29	1	518	321	non	1	-	-
E	577	BB	24-07-2006	17-07-2006	1	1	28.7	28.7 | 28.7	-	2	24 29	1	538	122	non	1	-	-
E	577	BB	19-11-2006	08-11-2006	1	1	48.6	48.6 | 48.6	-	3	-	2	311	757	non	1	10	-
E	636	BB	22-02-2006	17-02-2006	1	1	44	44 | 44	-	3	-	1	333	447	non	1	12	-
E	636	BB	26-09-2006	18-09-2006	1	1	32.6	32.6 | 32.6	-	3	-	1	401	106	non	1	9	-
E	642	PS	06-01-2006	19-12-2005	1	1	55	55 | 55	55	3	-	4	209	1654	non	1	2	-
E	642	PS	15-04-2006	20-02-2006	1	1	40	40 | 40	40	1	24	1	202	602	non	1	1	-
E	642	PS	01-06-2006	20-05-2006	1	1	100	100 | 100	100	1	24	4	444	450	non	1	7	-
E	642	PS	01-08-2006	18-06-2006	1	1	85	85 | 85	85	1	24	1	534	226	non	1	1	-
E	642	PS	29-09-2006	08-09-2006	1	1	135	135 | 135	135	1	24	3	200	1848	non	1	12	-
E	642	PS	15-11-2006	10-11-2006	1	1	210	210 | 210	210	1	21	4	120	1310	non	1	9	-
E	642	PS	14-12-2006	06-12-2006	1	1	70	70 | 70	70	1	21	3	7	1236	non	1	8	-
E	643	PS	11-02-2006	28-01-2006	1	1	70	70 | 70	70	3	-	3	115	1454	non	1	11	-
E	643	PS	11-02-2006	08-02-2006	2	1	30	30 | 30	-	1	?	1	130	6	non	1	-	-
E	643	PS	21-03-2006	25-02-2006	1	1	35	35 | 35	-	1	?	3	244	205	non	1	-	-
E	643	PS	21-03-2006	21-03-2006	1	1	40	40 | 40	40	3	-	1	444	18	non	1	24	-
E	643	PS	23-05-2006	18-05-2006	1	1	66	66 | 66	66	1	24	3	243	1144	non	1	7	-
E	643	PS	24-06-2006	11-06-2006	1	1	65	65 | 65	65	1	24	3	57	534	non	1	1	-

Check and correct the Association Code for the corresponding activity in the logbook

The declaration of fishing mode (fad, fsc, unk) is inconsistent with associations (context of fishing: birds, DCP, etc.). If you have only one association with C_ASSOC_G=2 (fad), then you must declare the set with fishing mode 'fad'.

TYPE_BANC		
C_TBANC	L_TBANC4L	L_TBANC
1	BO	Banc sous objet
2	BL	Banc libre
3	IND	Indéterminé

ASSOC			
C_ASSOC	L_ASSOC	C_ASSOC_R	C_ASSOC_G
21	EPAVE NATURELLE (tas de paille, bille de bois ....)	1	1
22	EPAVE NATURELLE BALISEE	1	1
23	EPAVE ARTIFICIELLE (caisse , bouée, cordage ....)	1	1
24	EPAVE ARTIFICIELLE BALISEE (radeau)	1	1
25	EPAVE ANCREE (D.C.P)	1	1
26	POISSON SOUS LE THONIER OU LE SKIFF	5	1
27	PECHE AVEC UN CANNEUR COMME AGREGATEUR	5	1
28	PECHE AVEC SUPPLY OU AUTRE BATEAU (autre que canneur) COMME AGREGATEUR	5	1
29	PECHE A LA SENNE AVEC APPATS	2	2

Echantillon (Sampling)

4.

Les échantillons :

E/W	Echantillon					Poids					Espèce				
-	C_BAT	Engin	D_DBQ	N_ECH	TYP_ECH	M10	P10	P_E	S_Poids	S_Pond	C_ESP	LDLF	NB_MES	%Petits	%Gros
E	365	BB	12-01-2006	4	1	166.1	33.7	0	199.8	35	1	2	67	100	0
E	365	BB	12-01-2006	4	1	166.1	33.7	0	199.8	35	2	2	30	100	0
E	365	BB	12-01-2006	4	1	166.1	33.7	0	199.8	35	3	2	88	100	0
E	365	BB	13-02-2006	14	1	248.8	36.6	0	285.4	50	1	2	77	100	0
E	365	BB	13-02-2006	14	1	248.8	36.6	0	285.4	50	2	2	60	100	0
E	365	BB	13-02-2006	14	1	248.8	36.6	0	285.4	50	3	2	46	100	0
E	365	BB	13-02-2006	14	1	248.8	36.6	0	285.4	50	6	2	30	100	0
E	365	BB	27-03-2006	27	1	283.7	16.4	0	300.1	30	1	2	100	100	0
E	365	BB	27-03-2006	27	1	283.7	16.4	0	300.1	30	2	2	60	100	0
E	365	BB	27-03-2006	27	1	283.7	16.4	0	300.1	30	3	2	26	100	0
E	365	BB	30-04-2006	11	1	188.6	11.4	0	200	30	1	2	127	100	0
E	365	BB	30-04-2006	11	1	188.6	11.4	0	200	30	2	2	60	100	0
E	365	BB	30-04-2006	11	1	188.6	11.4	0	200	30	3	2	50	100	0
E	365	BB	05-06-2006	8	1	272.6	27.8	0	300.4	47	1	2	66	100	0
E	365	BB	05-06-2006	8	1	272.6	27.8	0	300.4	47	2	2	60	100	0
E	365	BB	05-06-2006	8	1	272.6	27.8	0	300.4	47	3	2	54	100	0
E	365	BB	05-06-2006	8	1	272.6	27.8	0	300.4	47	6	2	49	100	0
E	365	BB	04-10-2006	6	1	282.1	13.5	0	295.6	70	1	2	126	100	0
E	365	BB	04-10-2006	6	1	282.1	13.5	0	295.6	70	2	2	60	100	0
E	365	BB	04-10-2006	6	1	282.1	13.5	0	295.6	70	3	2	15	100	0

???

A comprehensive and accurate position of the sets should be given in the well plan.
In addition, getting the scans of the original documents would be very useful to understand why such figures have been entered

Appendix 2. R and SQL codes to compute the yearly total landings and catches from the AVDTH 2008-2011 database

```
#Connect to the database
require(RODBC)
database <- "Merged_data_2008_2011_V3.3.mdb"
chemin <- odbcConnectAccess(database)

# TABLE "MAREE" FROM AVDTH
# Get the total landings by year, gear, and species
qry_yearly_landings_species <- "SELECT tt.gear AS [GearGrp], tt.year AS [YearC], tt.species AS
[Species], ROUND(SUM(tt.weight),3) AS [Landings]
FROM (SELECT IIf(BATEAU.C_TYP_B In (4,5,6),'PS',IIf(BATEAU.C_TYP_B In
(1,2,3),'BB','OTHER')) AS gear,DatePart('yyyy',MAREE.D_DBQ) AS year, ESPECE.C_ESP_3L AS
species,LOT_COM.v_poids_lc AS weight
FROM TYPE_BATEAU INNER JOIN (PAYS INNER JOIN ((CAT_BATEAU INNER JOIN
(BATEAU INNER JOIN (PORT INNER JOIN MAREE ON PORT.C_PORT =
MAREE.C_PORT_DBQ)
ON BATEAU.C_BAT = MAREE.C_BAT) ON CAT_BATEAU.C_CAT_B = BATEAU.C_CAT_B)
INNER JOIN (ESPECE INNER JOIN (CAT_COM INNER JOIN LOT_COM ON
(CAT_COM.C_CAT_C = LOT_COM.C_CAT_C)
AND (CAT_COM.C_ESP = LOT_COM.C_ESP)) ON ESPECE.C_ESP = CAT_COM.C_ESP) ON
(MAREE.D_DBQ = LOT_COM.D_DBQ) AND (MAREE.C_BAT = LOT_COM.C_BAT))
ON PAYS.C_PAYS = BATEAU.C_PAYS) ON TYPE_BATEAU.C_TYP_B = BATEAU.C_TYP_B
) AS tt GROUP BY tt.gear, tt.year,tt.species;"

yearly_landings_species <- sqlQuery(channel=chemin,query=qry_yearly_landings_species)
sum_landings <-
aggregate(yearly_landings_species$Landings,by=list(YearC=yearly_landings_species$YearC,GearGr
p=yearly_landings_species$GearGrp),sum)
names(sum_landings)[2:3] <- c("GearGrp","Landings")

# TABLE "CAPT_ELEM" FROM ADVTH
qry_yearly_catches_species <- "SELECT tt.gear AS [GearGrp], tt.year AS [YearC], tt.species AS
[Species], ROUND(SUM(tt.catch),3) AS [Catches]
FROM (SELECT IIf(BATEAU.C_TYP_B In (4,5,6),'PS',IIf(BATEAU.C_TYP_B In
(1,2,3),'BB','OTHER')) AS gear, YEAR(ACTIVITE.D_ACT) AS [year], ESPECE.C_ESP_3L AS
species,CAPT_ELEM.V_POIDS_CAPT AS catch
FROM ((TYPE_BATEAU INNER JOIN (ACTIVITE INNER JOIN BATEAU ON
ACTIVITE.C_BAT = BATEAU.C_BAT) ON TYPE_BATEAU.C_TYP_B = BATEAU.C_TYP_B)
INNER JOIN CAPT_ELEM ON (ACTIVITE.N_ACT = CAPT_ELEM.N_ACT) AND
(ACTIVITE.D_ACT = CAPT_ELEM.D_ACT) AND (ACTIVITE.D_DBQ = CAPT_ELEM.D_DBQ)
AND (ACTIVITE.C_BAT = CAPT_ELEM.C_BAT)) INNER JOIN ESPECE ON
CAPT_ELEM.C_ESP = ESPECE.C_ESP
) AS tt GROUP BY tt.gear, tt.year,tt.species;"
yearly_catches_species <- sqlQuery(channel=chemin,query=qry_yearly_catches_species)

# Get the total catches by year, gear, and species
sum_catches <-
aggregate(yearly_catches_species$Catches,by=list(YearC=yearly_catches_species$YearC,GearGrp=y
early_catches_species$GearGrp),sum)
names(sum_catches)[2:3] <- c("GearGrp","Catches")
```

Appendix 3. R and SQL codes to compute the yearly number of active vessels from the AVDTH 2008-2011 database

```
### Libraries
require(RODBC)

#Connect to the database
setwd(rep.data)
database <- "Merged_data_2008_2011_V3.3.mdb"
chemin <- odbcConnectAccess(database)

# TABLE "MAREE" FROM AVDTH
# Get the list of active vessels by year and gear
qry_yearly_vessels_maree <- "SELECT NB1.gear, NB1.year, c_quille AS keel_code,c_bat AS
vessel_code,l_bat AS vessel_name
FROM (		SELECT IIf(b.c_typ_b In (4,5,6),'PS',IIf(b.c_typ_b In (1,2,3),'BB','OTHER')) AS
gear, year(m.d_dbq) AS [year], IIf(DatePart('q',m.d_dbq) In (1,2),1,2) AS semester,
DatePart('q',m.d_dbq) AS QUARTER, m.c_bat, b.c_quille,b.l_bat FROM (maree AS m INNER JOIN
bateau AS b ON m.c_bat = b.c_bat) GROUP BY b.c_typ_b, year(m.d_dbq), DatePart('q',m.d_dbq),
m.c_bat, b.l_bat,b.c_quille) AS NB1
GROUP BY NB1.gear,NB1.year,c_bat,c_quille,l_bat
ORDER BY NB1.gear,NB1.year,c_bat,c_quille,l_bat;"
yearly_vessels_maree <- sqlQuery(channel=chemin,query=qry_yearly_vessels_maree)

### Compute the number of active vessels by year from MAREE
vessels_maree <-
aggregate(yearly_vessels_maree$keel_code,by=list(YearC=yearly_vessels_maree$year,GearGrp=year
ly_vessels_maree$gear),function(x) length(unique(x)))
names(vessels_maree)[3] <- "n_maree"

# TABLE "ACTIVITE" FROM AVDTH
# Get the list of active vessels by year and gear
qry_yearly_vessels_activite <- "SELECT NB1.gear, NB1.year, c_quille AS keel_code,c_bat AS
vessel_code,l_bat AS vessel_name
FROM (SELECT IIf(b.c_typ_b In (4,5,6),'PS',IIf(b.c_typ_b In (1,2,3),'BB','OTHER')) AS gear,
year(a.D_ACT) AS [year], IIf(DatePart('q',a.D_ACT) In (1,2),1,2) AS semester, DatePart('q',a.d_act)
AS QUARTER, a.c_bat, b.c_quille,b.l_bat FROM (activite AS a INNER JOIN bateau AS b ON
a.c_bat = b.c_bat) GROUP BY c_typ_b, year(a.d_act), DatePart('q',a.d_act), a.c_bat,
b.l_bat,b.c_quille) AS NB1
GROUP BY NB1.gear,NB1.year,c_bat,c_quille,l_bat
ORDER BY NB1.gear,NB1.year,c_bat,c_quille,l_bat;"
yearly_vessels_activite <- sqlQuery(channel=chemin,query=qry_yearly_vessels_activite)

### Compute the number of active vessels by year from MAREE
vessels_activite <-
aggregate(yearly_vessels_activite$keel_code,by=list(YearC=yearly_vessels_activite$year,GearGrp=y
early_vessels_activite$gear),function(x) length(unique(x)))
names(vessels_activite)[3] <- "n_activite"
```

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ESTADÍSTICAS ESPAÑOLAS DE LA PESQUERÍA ATUNERA TROPICAL, EN EL OCÉANO ATLÁNTICO, HASTA 2012.

A. Delgado de Molina[1], J.C. Santana[1], J. Ariz[1] y V. Rojo[2]

SUMMARY

This paper presents data about catches, fishing efforts, catches per unit of effort and sampling coverage of the Spanish tropical tuna fleet (purse seiners and bait boats) that fish in the Atlantic Ocean.

RÉSUMÉ

Ce document présente des données relatives à la prise, à l'effort de pêche, à la capture par unité d'effort et à la couverture d'échantillonnage de la flottille thonière tropicale espagnole (senneurs et canneurs) se livrant à des activités de pêche dans l'océan Atlantique.

RESUMEN

En este documento se presentan datos de capturas, esfuerzos, capturas por unidad de esfuerzo y coberturas de muestreos de la flota atunera tropical española de cerco y de cañeros que faena en el Océano Atlántico.

KEYWORDS

Océano Atlántico, túnidos tropicales, cerco, cebo vivo, capturas, esfuerzo de pesca, objetos flotantes, tallas, CPUE

1 Datos de base.

Los datos de base para la realización del presente trabajo, proceden, en su mayoría, de los cuadernos de pesca que cumplimentan la flota y de la Red de Información y Muestreo que el Instituto Español de Oceanografía tiene establecida en los principales puertos de desembarco.

El tratamiento previo para el cálculo de las capturas totales por especie (corrección de la composición específica), medida del esfuerzo pesquero y captura por unidad de esfuerzo se hacía en base a los resultados obtenidos en el Grupo de Trabajo sobre Túnidos Tropicales Juveniles, descrito en trabajos anteriores (ICCAT, 1984; Fonteneau, 1981). Los datos revisados del periodo reciente se han obtenidos siguiendo un nuevo esquema estadístico que incorpora los distintos tipos de asociación de las pescas (Pallarés, P. et Ch. Petit, 1998). Las cifras presentadas en este documento son provisionales.

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Pallarés, P. y Ch. Petit, 1998. Túnidos tropicales: nueva estrategia de muestreo y tratamiento de datos para estimar la composición específica de las capturas y sus distribuciones de tallas. Vol. Sci. Pap . ICCAT 48 (2):230 – 246 pp.

Tabla 1. Número de barcos y capacidad de transporte de la flota de cerco española en el Océano Atlántico.

AÑO	*NB*	*Capacidad Transporte (*)*
1990	35	19717
1991	38	23780
1992	35	23630
1993	31	19371
1994	30	19113
1995	24	16066
1996	24	14211
1997	20	11364
1998	19	12082
1999	18	9198
2000	19	11051
2001	17	11442
2002	16	9946
2003	15	10017
2004	15	9559
2005	10	5460
2006	8	4258
2007	13	6175
2008	15	9969
2009	16	13326
2010	15	13211
2011	15	13339
2012	14	10665

(*) La capacidad de transporte en toneladas (t) está ponderada al tiempo de actividad.

Tabla 2. Número de barcos por categoría (según la capacidad de transporte) de la flota de cerco española que faena en el Océano Atlántico.

Año / Categ.	*50 – 400*	*401 - 600*	*601 - 800*	*801 – 1200*	*1201 – 2000*	*>2000*	*TOTAL*
1990	1	14	6	9	5		35
1991	1	16	5	9	6	1	38
1992	1	16	4	7	6	1	35
1993	1	13	4	6	6	1	31
1994	1	14	4	5	5	1	30
1995	1	13	3	3	4		24
1996	1	13	3	3	4		24
1997	1	12	3	2	2		20
1998		12	3	1	2		18
1999		12	2	1	3		18
2000		12	3	2	2		19
2001		10	3	2	2		17
2002		9	2	2	3		16
2003		9	2	2	2		15
2004	1	8	2	2	2		15
2005		6	2	1	1		10
2006		6	2				8
2007		6	3	2	2		13
2008		6	2	3	4		15
2009		6	2	4	4		16
2010		5	2	4	4		15
2011		5	2	4	4		15
2012		5	2	3	4		14

Tabla 3. Capturas, en toneladas, de la flota atunera tropical española en el Atlántico Este para el periodo comprendido entre 1990 y 2012.

AÑO	*Rabil*	*Listado*	*Patudo*	*Otros*	*TOTAL*
1990	66201	43189	6060	1680	117129
1991	50824	74139	8628	996	134585
1992	47972	46125	8789	2070	104956
1993	38925	60387	11755	1130	112197
1994	38806	45288	12067	1152	97313
1995	37137	45847	9597	945	93526
1996	31845	33527	8813	1805	75990
1997	23510	31449	5979	1397	62334
1998	27778	27414	4534	1469	61195
1999	19670	38664	5923	1028	65284
2000	23033	31209	6043	740	61025
2001	30284	27543	5927	1031	64785
2002	30343	21595	7037	431	59407
2003	23330	37658	6372	784	68144
2004	20086	31514	3943	489	56031
2005	10979	18005	3012	148	32143
2006	10453	14537	3328	16	28334
2007	12766	17292	3310	262	33629
2008	23287	26760	5266	577	55890
2009	31861	28047	7769	1156	68834
2010	23839	32781	7699	1021	65339
2011	17880	44981	10095	1097	74052
2012	17758	47202	7387	1706	74054

Tabla 4. Capturas, en toneladas, de la flota atunera tropical española en el Atlántico Este para objeto y banco libre, para el periodo comprendido entre 1991 y 2011.

AÑO	*Rabil*		*Listado*		*Patudo*		*Otros*		*TOTAL*	
	OB	*BL*	*OB*	*BL*	*OB*	*BL*	*OB*	*BL*	*OB*	*BL*
1991	9336	41488	53859	20279	7891	736	614	381	71701	62884
1992	8011	39961	36065	10060	7700	1088	143	1926	51920	53035
1993	7948	30978	33458	26929	9489	2266	218	912	51113	61085
1994	7848	30958	26250	19038	10469	1598	233	918	44800	52513
1995	8402	28735	31816	14031	8519	1078	533	413	49270	44257
1996	7516	24329	27786	5741	8116	697	1513	292	44930	31060
1997	4076	19434	16106	15343	5280	699	922	474	26384	35950
1998	2991	24788	10542	16871	3556	978	517	953	17605	43590
1999	3287	16383	14285	24379	4951	971	494	535	23017	42268
2000	5429	17603	20625	10584	5210	834	587	153	31851	29173
2001	4615	25669	19316	8227	5040	886	903	128	29875	34910
2002	4749	25594	16428	5167	5608	1430	374	58	27158	32249
2003	4457	18873	19475	18183	4906	1466	473	311	29310	38834
2004	3816	16270	16949	14564	3021	922	267	221	24054	31977
2005	3404	7575	14290	3715	2481	530	146	2	20321	11822
2006	3163	7289	11118	3420	2086	1242	1	15	16368	11967
2007	2832	9934	15631	1662	2077	1232	262	-	20801	12828
2008	6619	16668	23947	2812	4545	721	475	102	35587	20303
2009	5435	26426	25793	2254	5749	2020	983	173	37960	30874
2010	6230	17609	29392	3389	6309	1390	962	59	42893	22446
2011	5932	11948	41275	3706	8727	1368	971	125	56905	17147
2012	4472	13286	45036	2166	5577	1809	1449	257	56534	17519

Tabla 5. Número de ejemplares muestreados (NºEj) de las distintas especies desembarcadas por la flota atunera tropical española y asimilada.

AÑO	*Rabil* *NºEj*	*Listado* *NºEj*	*Patudo* *NºEj*	*Otros* *NºEj*	*Total* *Nº Ej.*
1990	32516	31627	2900	966	68009
1991	23099	48685	4540	3375	79699
1992	21055	31215	5017	4494	61781
1993	11670	19718	3130	2772	37290
1994	13046	19880	3352	1911	38189
1995	49272	70847	13226	9301	142646
1996	47318	70141	17227	11560	146246
1997	30164	46576	9146	8276	94162
1998	61967	86308	15606	13870	177751
1999[1]	53249	97681	10062	22156	183148
2000	41333	19759	19930	10657	91679
2001	34594	14735	15642	6915	71886
2002	32912	14950	18863	115	66840
2003	36569	30569	22941	14577	104656
2004	61048	48652	32440	20880	163020
2005	38920	30805	22178	11713	103616
2006	41827	39299	25321	14918	121365
2007	35400	31109	19334	15515	101358
2008	51924	39046	30670	17592	139232
2009	60981	39403	34498	18695	153577
2010	45333	39068	35334	22298	142023
2011	38765	45304	39828	16987	140884
2012	35733	36570	24343	16922	113568

1 En este año se incluyen además de los muestreos de la flota española y asimilada, los de la francesa.

Tabla 6. Número total de cuadriculas de grado por grado exploradas por la flota de cerco española, número de cuadrículas con lance, con captura, con esfuerzo superior a 12 y 60 horas.

NUMERO DE CUADRICULAS 1ºX1º PROSPECTADAS POR LA FLOTA ESPAÑOLA					
AÑO	*N. CWP*	*N. CWP con LANCE*	*N. CWP con CAPTURA*	*N. CWP Esf. >12hrs*	*N. CWP Esf. >60hrs*
1991	492	383	375	398	265
1992	487	390	380	452	301
1993	467	329	314	437	253
1994	478	350	335	412	270
1995	483	373	362	396	247
1996	489	397	386	464	303
1997	529	387	368	428	260
1998	553	363	339	455	241
1999	502	363	347	454	248
2000	524	397	381	427	239
2001	549	414	398	441	249
2002	527	382	368	466	254
2003	482	370	358	384	198
2004	522	382	373	376	202
2005	443	317	307	335	162
2006	410	263	261	288	132
2007	487	335	327	347	169
2008	556	437	427	416	189
2009	644	496	485	443	204
2010	624	464	456	434	218
2011	686	542	534	489	207
2012	624	506	493	417	178

Tabla 7. Esfuerzo en Días Pesca de la flota de cerco (PS) española en el Océano Atlántico Este (1991 – 2012).

AÑO	*ESFUERZO Días Pesca*
1991	8562
1992	9347
1993	8854
1994	8146
1995	7121
1996	6756
1997	5752
1998	5684
1999	5664
2000	4697
2001	4798
2002	4667
2003	4103
2004	3865
2005	2574
2006	2165
2007	2733
2008	3581
2009	4371
2010	4180
2011	4170
2012	3569

Tabla 8. Número de lances, lances positivos, lances nulos y captura media, en toneladas, por lance positivo, de la flota de cerco española en el Océano Atlántico Este (1990– 2012).

Año	*Nº de lances*	*Positivos*	*Nulos*	*Cap. Media por lance (t)*
1990	5148	3836	1312	30.5
1991	5702	4570	1132	29.4
1992	4477	3448	1029	30.4
1993	4527	3545	982	31.6
1994	4389	3481	908	28.0
1995	4460	3534	926	26.5
1996	3381	2754	627	27.6
1997	2966	2450	516	25.4
1998	3313	2631	682	23.3
1999	2338	1887	451	34.6
2000	2665	2200	465	27.7
2001	2715	2164	551	29.9
2002	2179	1777	402	33.4
2003	2669	2309	360	29.5
2004	1946	1715	231	32.7
2005	1266	1104	162	29.1
2006	926	811	115	34.9
2007	1322	1130	192	29.8
2008	2231	1923	308	29.1
2009	2929	2496	433	27.6
2010	3063	2601	462	25.1
2011	2966	2556	410	29.0
2012	2667	2387	280	31.0

Tabla 9. Número de lances positivos, lances nulos y captura media, en toneladas, por lance positivo, para objeto y banco libre de la flota de cerco española en el Océano Atlántico Este (1991 – 2012).

	OBJETOS			*BANCO LIBRE*		
AÑO	*Positivos*	*Nulos*	*Cap. Media*	*Positivos*	*Nulos*	*Cap. Media*
			Por lance (t)			*Por lance (t)*
1991	1851	124	38.7	2719	1008	23.1
1992	1544	80	33.6	1904	949	27.9
1993	1151	58	44.4	2394	924	25.5
1994	1154	25	38.8	2327	883	22.6
1995	1655	96	29.8	1879	830	23.6
1996	1540	89	29.2	1214	538	25.6
1997	1181	34	22.3	1269	482	28.3
1998	774	53	22.7	1857	629	23.5
1999	635	35	36.2	1252	416	33.8
2000	982	58	32.4	1218	407	24.0
2001	896	65	33.3	1268	486	27.5
2002	791	37	34.4	986	365	32.7
2003	859	20	34.1	1450	340	26.8
2004	750	22	32.1	965	209	33.1
2005	608	13	33.4	496	149	23.8
2006	473	20	34.6	338	95	35.4
2007	665	26	31.3	465	166	27.6
2008	1231	42	29.0	692	266	29.3
2009	1365	67	27.8	1131	366	27.3
2010	1678	77	25.6	923	385	24.4
2011	1914	103	29.7	642	307	26.8
2012	1753	78	32.3	634	202	27.6

Tabla 10. CPUE (toneladas/días pesca) de la flota de cerco española en el Océano Atlántico Este (1991 – 2012).

AÑO	*YFT*	*SKJ*	*BET*	*TOTAL(*)*
1991	5.94	8.66	1.01	15.72
1992	5.13	4.93	0.94	11.23
1993	4.40	6.82	1.33	12.67
1994	4.76	5.56	1.48	11.95
1995	5.22	6.44	1.35	13.13
1996	4.71	4.96	1.30	11.25
1997	4.09	5.47	1.04	10.84
1998	4.89	4.82	0.80	10.77
1999	3.47	6.83	1.05	11.53
2000	4.90	6.64	1.29	12.99
2001	6.31	5.74	1.24	13.50
2002	6.50	4.63	1.51	12.73
2003	5.69	9.18	1.55	16.61
2004	5.20	8.15	1.02	14.50
2005	4.27	7.00	1.17	12.49
2006	4.83	6.71	1.54	13.09
2007	4.67	6.33	1.21	12.30
2008	6.50	7.47	1.47	15.61
2009	7.29	6.42	1.78	15.75
2010	5.70	7.84	1.84	15.64
2011	4.29	10.79	2.42	17.76
2012	4.98	13.23	2.07	20.75

(*) Incluye todas las especies.

Tabla 11. Número de ejemplares y peso medio (kg.), de rabil, patudo y listado capturados por la flota española de cerco (PS).

	YFT		*BET*		*SKJ*	
AÑO	*Nº Ejem.*	*PM*	*Nº Ejem.*	*PM*	*Nº Ejem.*	*PM*
1990	3494727	19	1454194	5	19786810	2
1991	2292955	22.2	1967026	4.5	34297610	2.2
1992	1908324	25.2	1975308	4.5	22291420	2.1
1993	1557834	25	2390442	4.9	28731110	2.1
1994	1370702	28.3	2386264	5.1	17337460	2
1995	1833890	20.3	2135462	4.5	23724420	1.9
1996	1695806	18.7	2190636	4.1	16890420	2
1997	1220927	17.8	1764392	3.4	14957010	1.9
1998	1232930	21.8	1190539	3.8	11966245	2
1999	1111517	17.3	1391658	3.8	19141893	2
2000	2188424	11	1809505	3.5	16625110	2
2001	2083915	14.2	1350308	4.4	12237910	2.1
2002	2040867	14.9	1862338	3.8	10817000	2.0
2003	1760130	13.3	1647399	3.9	18237598	2.1
2004	1682341	11.9	1081838	3.6	15606310	2.0
2005	1196757	9.2	839103	3.6	9119826	2.0
2006	1018524	10.3	692831	4.8	7098856	2.0
2007	1125439	11.3	711614	4.6	9515680	1.8
2008	2652008	8.8	1686668	3.1	13810490	1.9
2009	2303142	13.8	1843995	4.2	15119796	1.9
2010	2607524	9.1	2310228	3.3	18468876	1.7
2011	2097293	8.5	2396881	4.2	24326440	1.8
2012	1530473	11.6	1704089	4.3	24362400	1.9

Tabla 12. Número de barcos y esfuerzo en días de pesca de la flota cañera españoles que faenan en el Atlántico este tropical (1995 – 2012).

AÑO	*NB*	*ESFUERZO* *Días Pesca*
1995	3	367
1996	4	450
1997	6	622
1998	7	909
1999	7	898
2000	7	515
2001	5	828
2002	9	1217
2003	11	1540
2004	12	1999
2005	9	1782
2006	6	1192
2007	5	993
2008	7	1660
2009	7	1606
2010	7	1619
2011	7	1647
2012	7	1563

Tabla 13. Capturas, en toneladas, de los cañeros españoles que faenan en el Atlántico este tropical (1995 – 2012).

AÑO	*RABIL*	*LISTADO*	*PATUDO*	*TOTAL*
1995	300	617	802	1719
1996	448	572	995	2015
1997	585	1191	701	2476
1998	251	3153	900	4304
1999	787	1488	2049	4324
2000	455	2683	1507	4644
2001	489	1618	898	3005
2002	830	3470	912	5228
2003	1207	5757	835	7819
2004	1079	5114	1315	7525
2005	692	7237	933	8946
2006	636	4628	1034	6372
2007	453	5370	969	6797
2008	632	4753	188	5704
2009	602	7055	824	8505
2010	736	6923	1060	8754
2011	1730	10417	1021	13168
2012	885	12124	637	13831

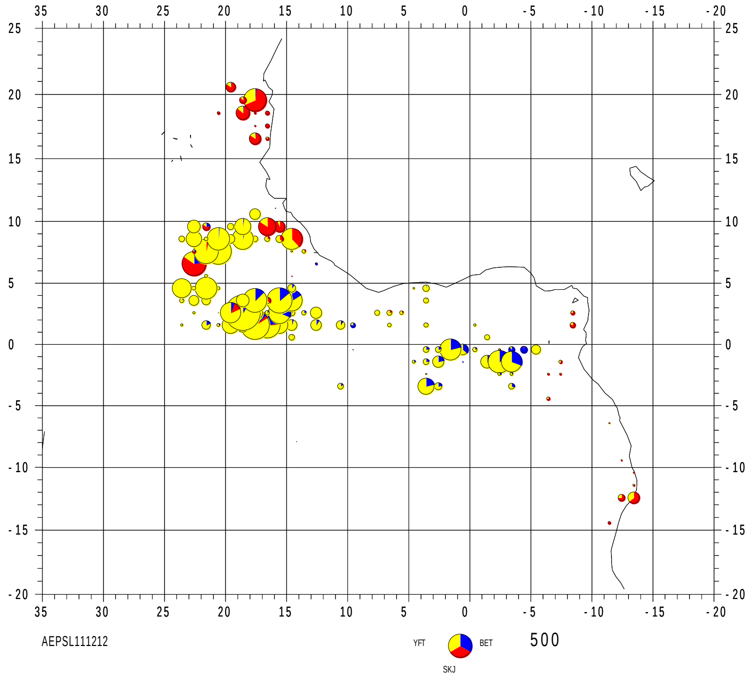

Figura 1. Distribución de las capturas de rabil, listado y patudo, sobre **bancos libres**, de la flota atunera española en 2012.

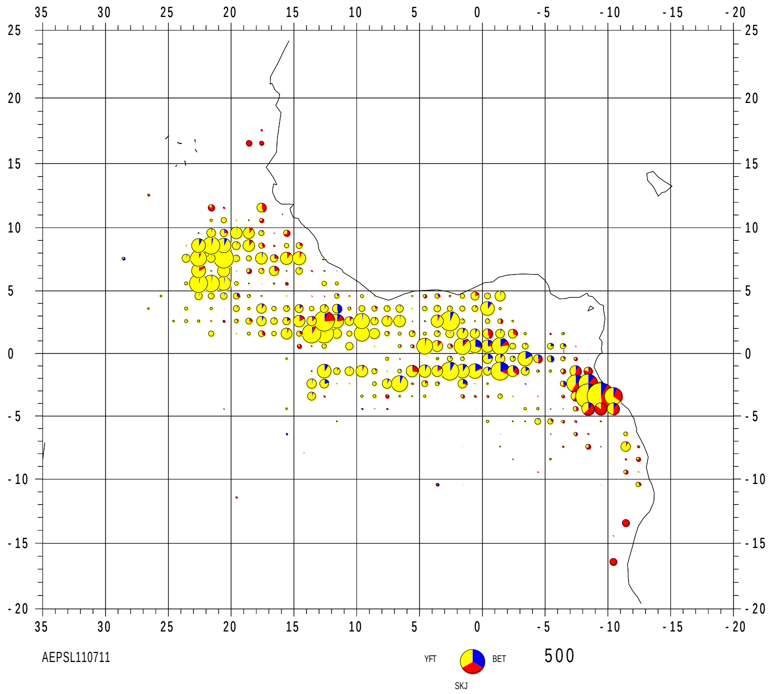

Figura 2. Distribución media de las capturas de rabil, listado y patudo, sobre **bancos libres**, de la flota atunera española para el periodo 2007 - 2011.

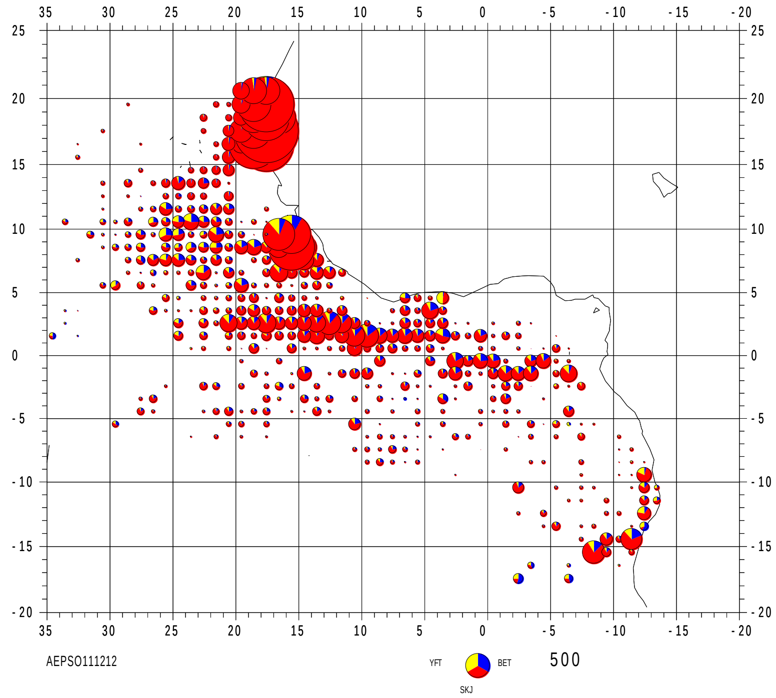

Figura 3. Distribución de las capturas de rabil, listado y patudo, sobre **objetos flotantes**, de la flota atunera española en 2012.

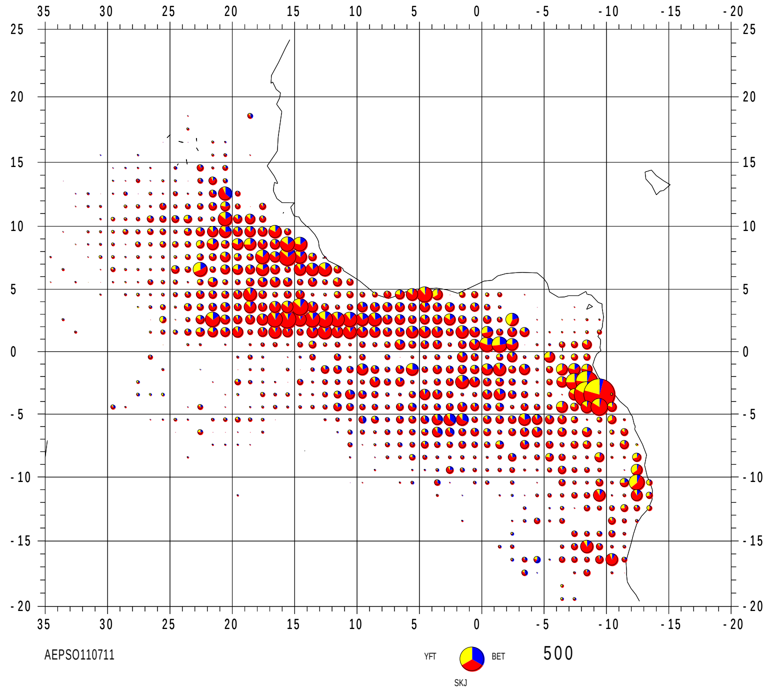

Figura 4. Distribución media de las capturas de rabil, listado y patudo, sobre **objetos flotantes**, de la flota atunera española para el periodo 2007 - 2011.

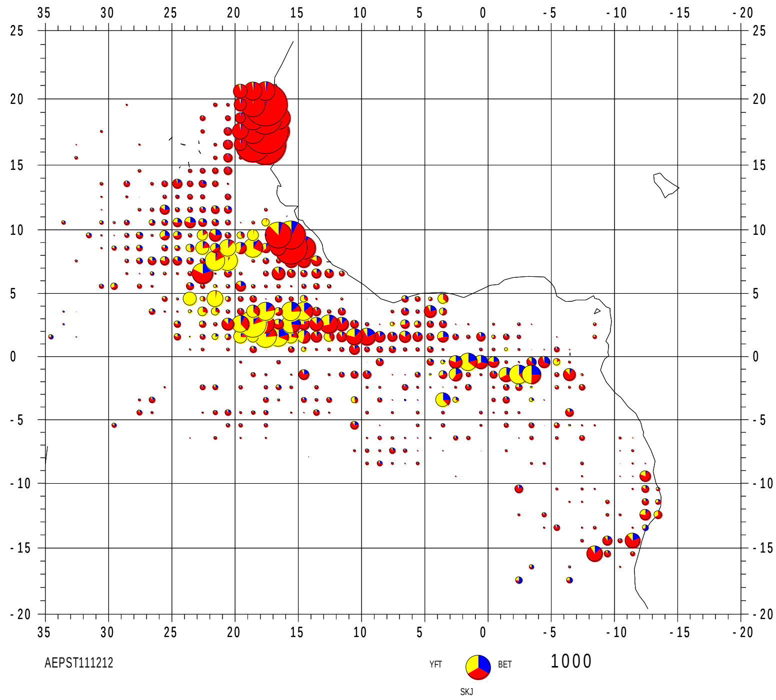

Figura 5. Distribución de las capturas de rabil, listado y patudo de la flota atunera española en 2012.

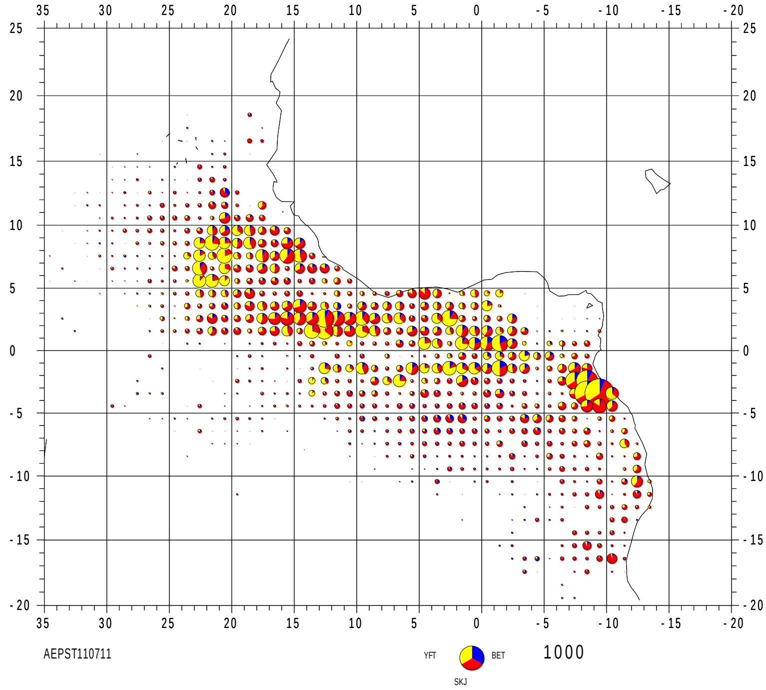

Figura 6. Distribución media de las capturas de rabil, listado y patudo de la flota atunera española. 2007 - 2011.

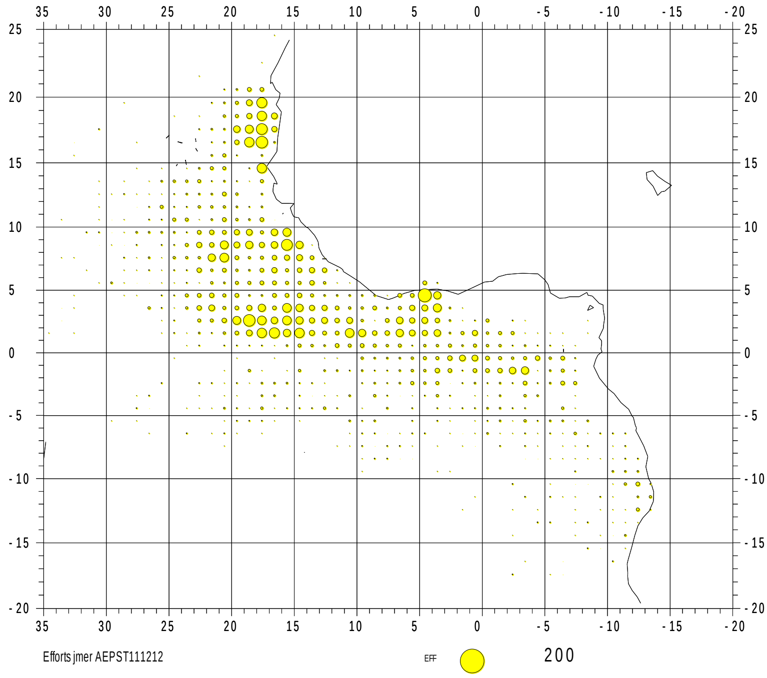

Figura 7. Esfuerzo total de la flota de cerco tropical española para el año 2012.

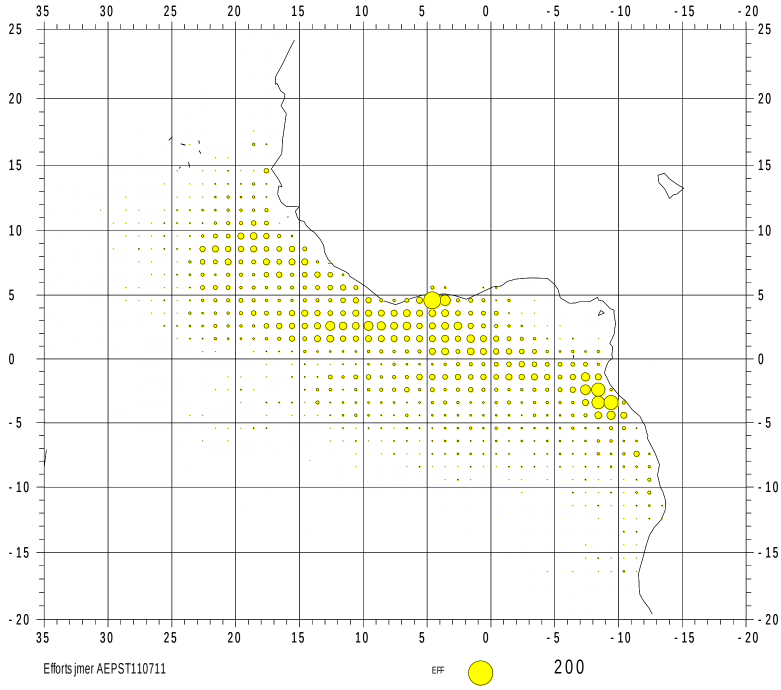

Figura 8. Esfuerzo medio de la flota de cerco tropical española para el periodo 2007 - 2011.

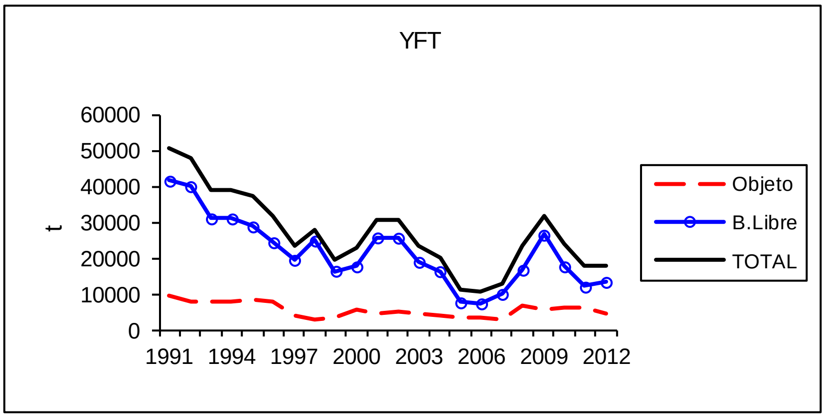

Figura 9. Capturas de rabil de la flota española de cerco tropical, por tipo de asociación.

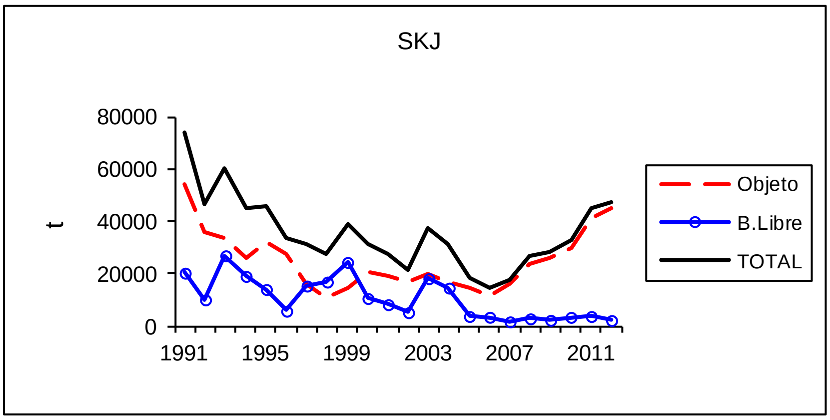

Figura 10. Capturas de listado de la flota española de cerco tropical, por tipo de asociación.

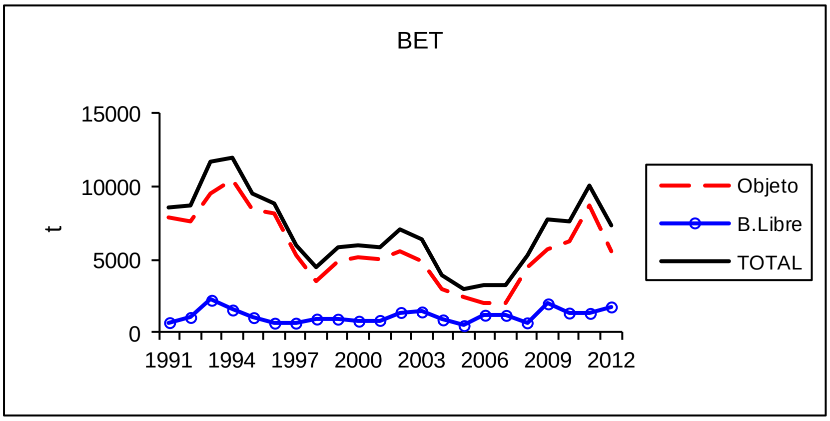

Figura 11. Capturas de patudo de la flota española de cerco tropical, por tipo de asociación.

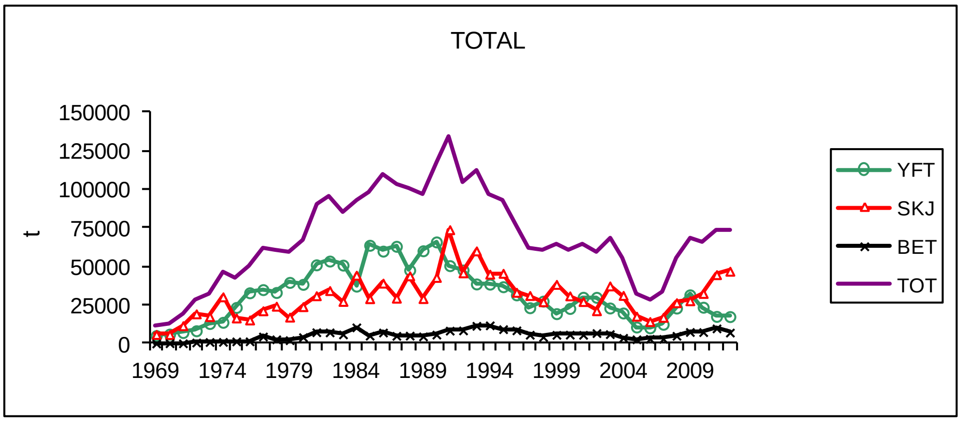

Figura 12. Capturas por especie de la flota española de cerco tropical.

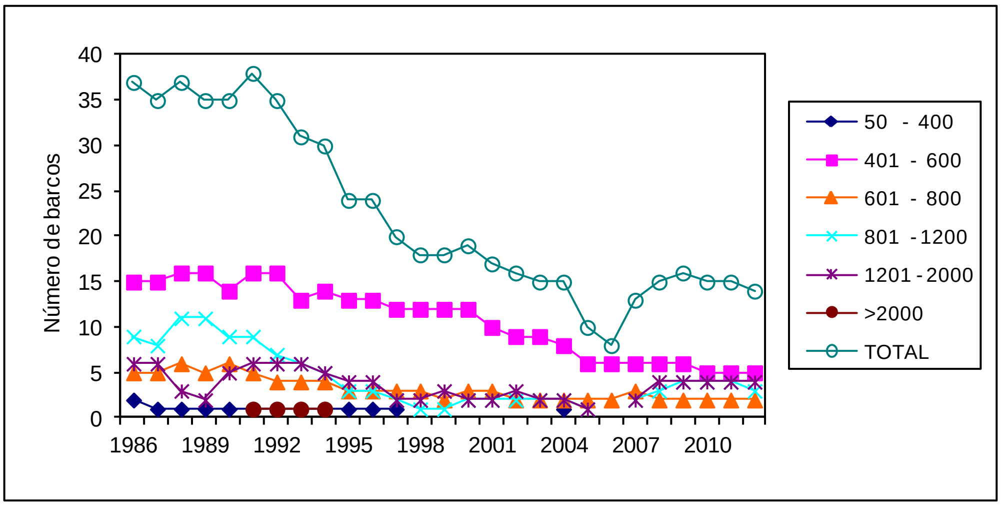

Figura 13. Número de barcos por categoría (según la capacidad de transporte) de la flota de cerco española que faena en el Océano Atlántico.

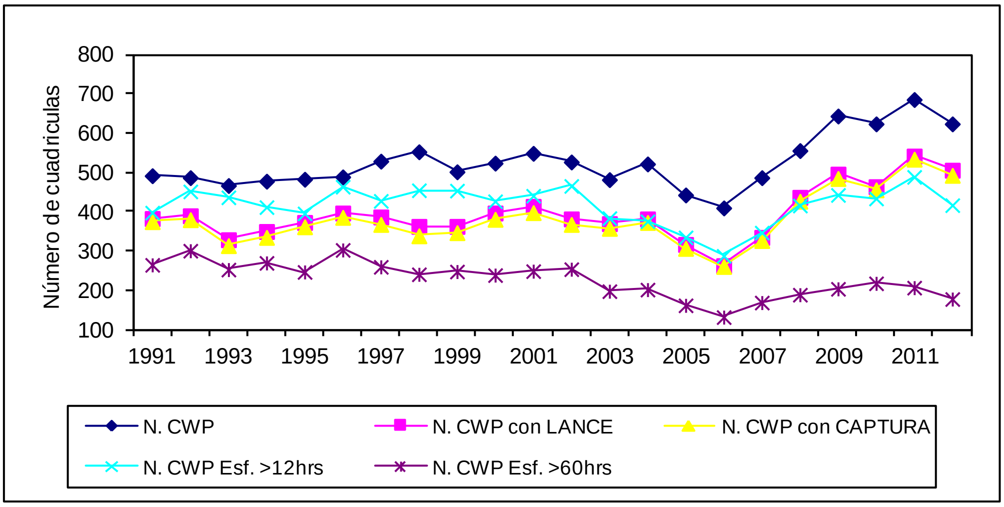

Figura 14. . Número total de cuadriculas de grado por grado visitadas por la flota de cerco española, número de cuadrículas con lance, con captura, con esfuerzo superior a 12 y 60 horas.

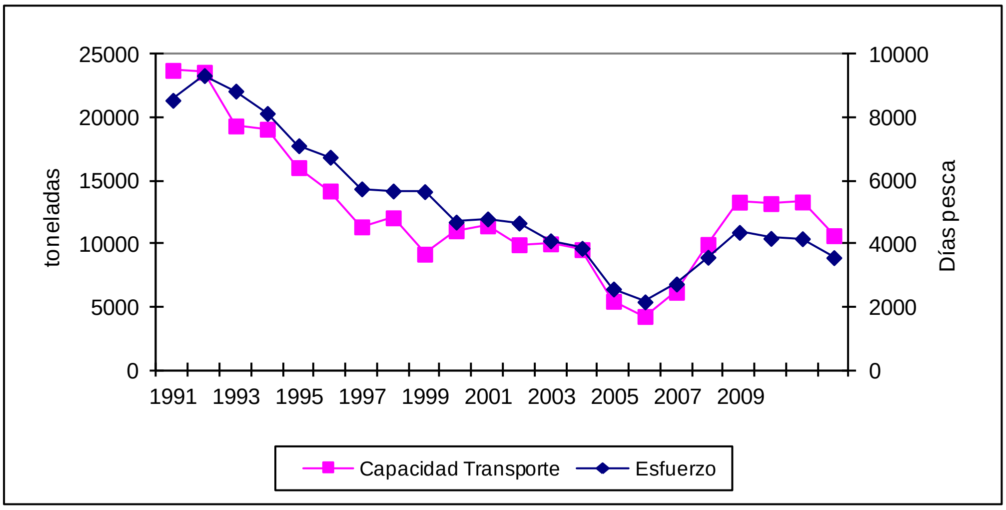

Figura 15. Capacidad de transporte y esfuerzo (en días pesca) de la flota española de cerco tropical.

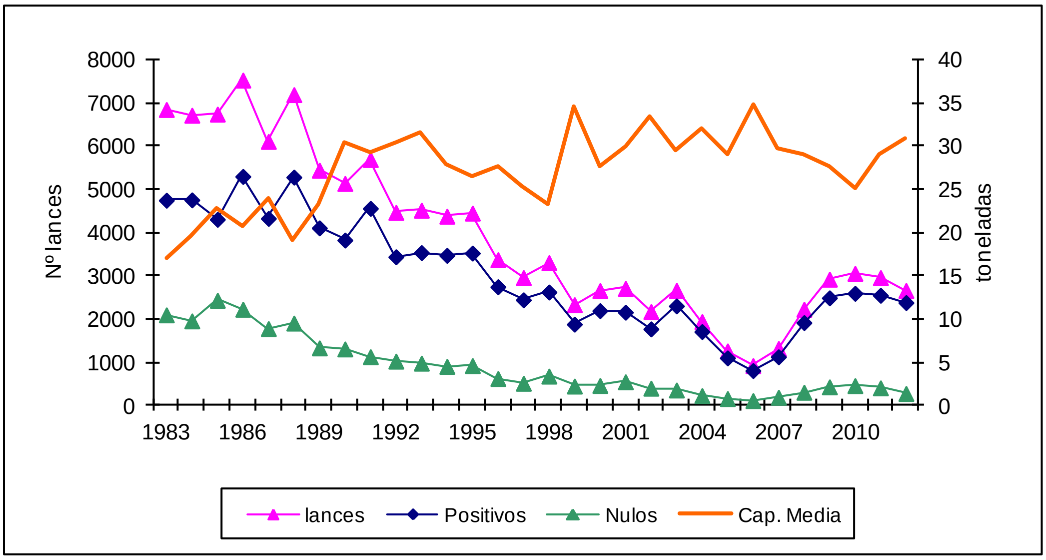

Figura 16. Número de lances positivos y lances nulos, para la flota de cerco española en el Océano Atlántico.

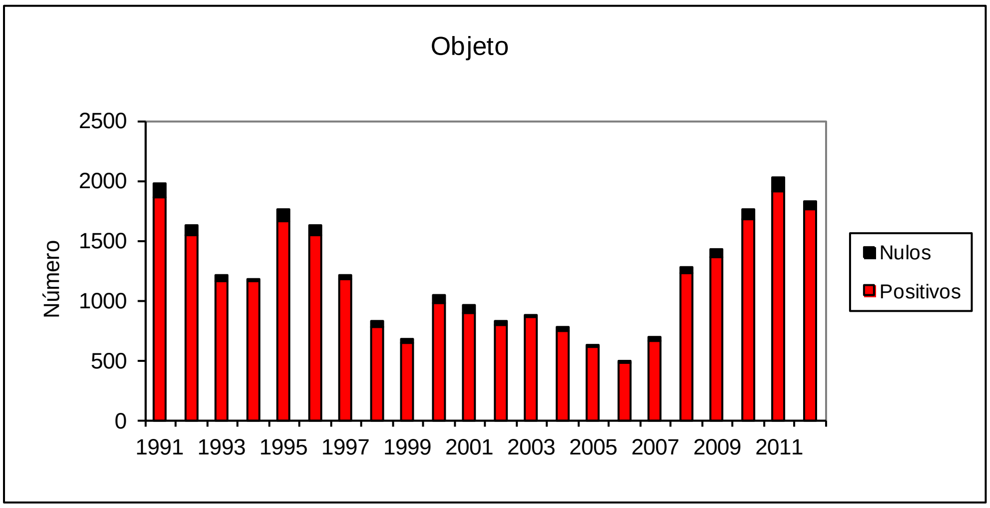

Figura 17. Número de lances positivos y lances nulos, para objetos flotantes, de la flota de cerco española en el Océano Atlántico

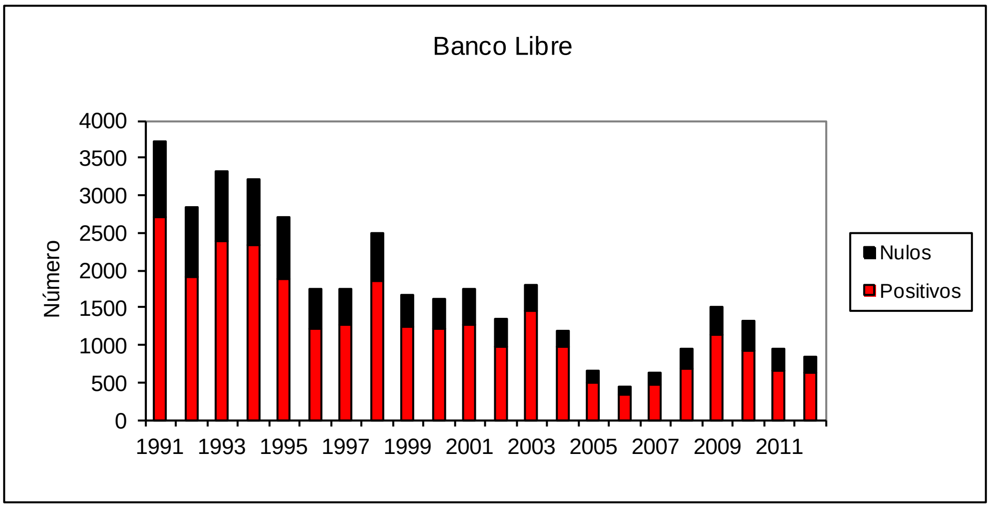

Figura 18. Número de lances positivos y lances nulos, para bancos libres, de la flota de cerco española en el Océano Atlántico.

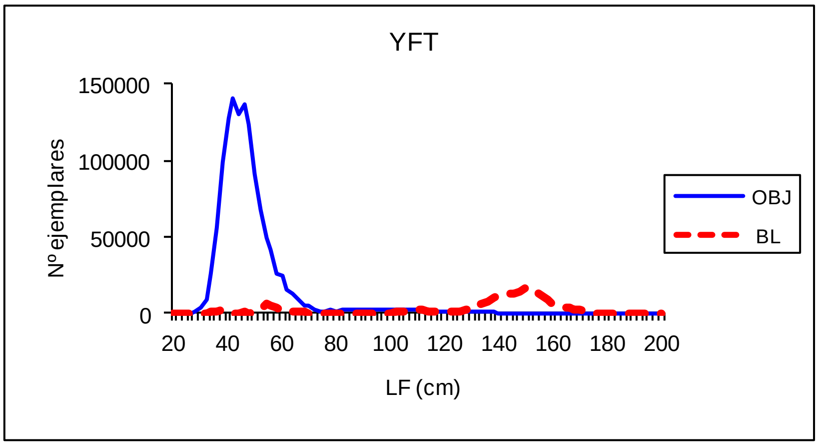

Figura 19. Distribución de tallas de rabil para la flota española de cerco tropical, por tipo de asociación, para el año 2012.

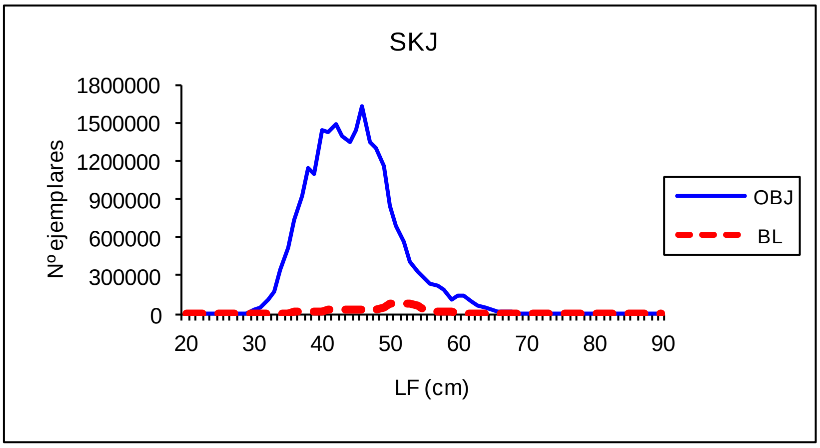

Figura 20. Distribución de tallas de listado para la flota española de cerco tropical, por tipo de asociación, para el año 2012.

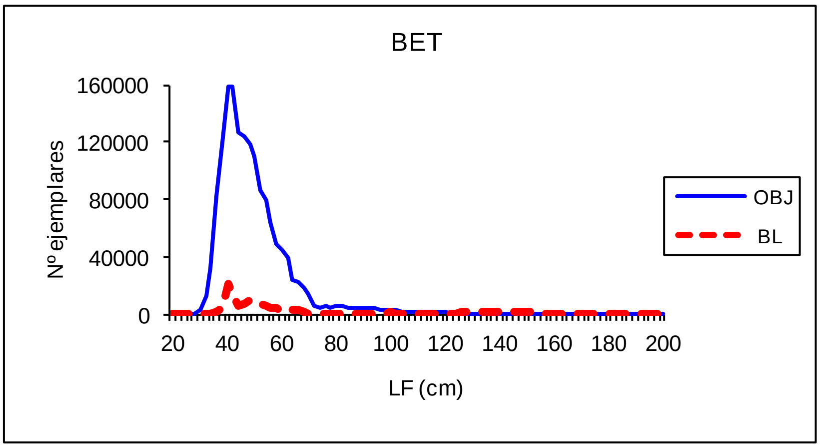

Figura 21. Distribución de tallas de patudo para la flota española de cerco tropical, por tipo de asociación, para el año 2012.

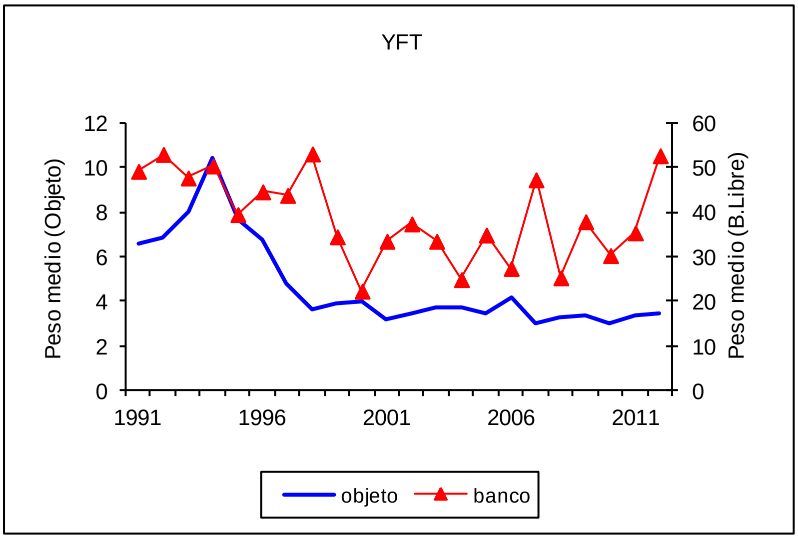

Figura 22. Pesos medios anuales de rabil, para objeto y banco libre, capturado por la flota española de cerco.

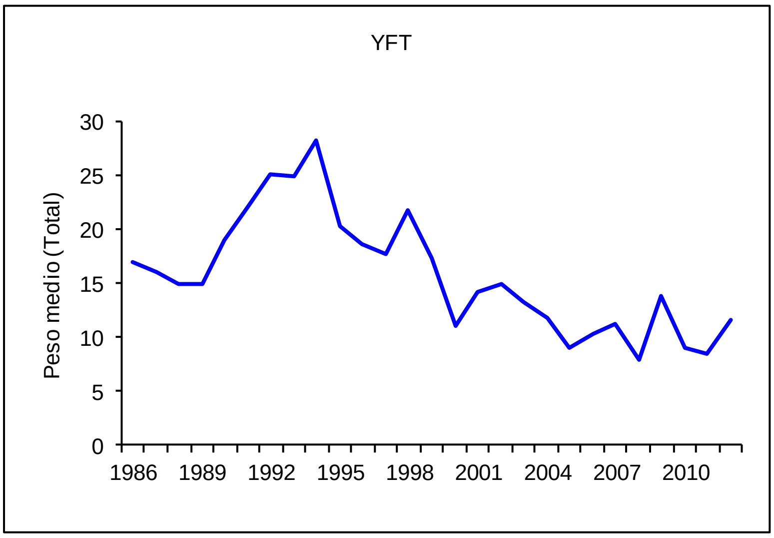

Figura 23. Pesos medios anuales de rabil, capturado por la flota española de cerco.

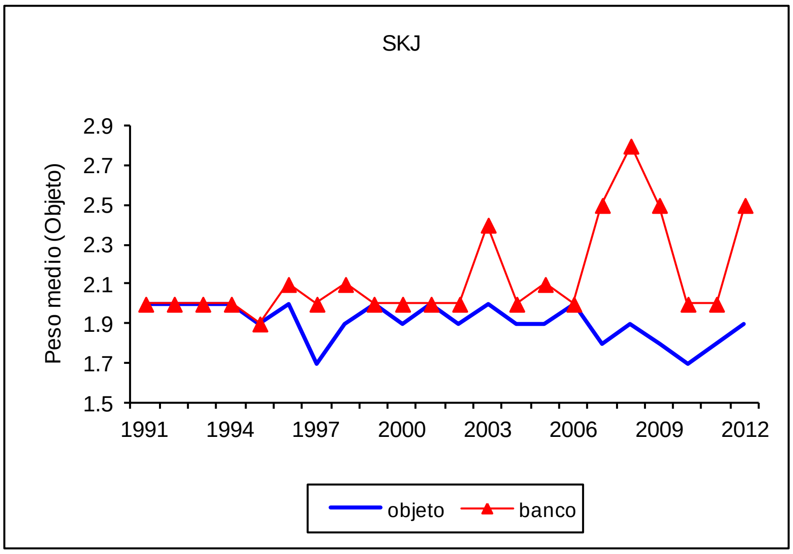

Figura 24. Pesos medios anuales de listado para objeto y banco libre, capturado por la flota española de cerco.

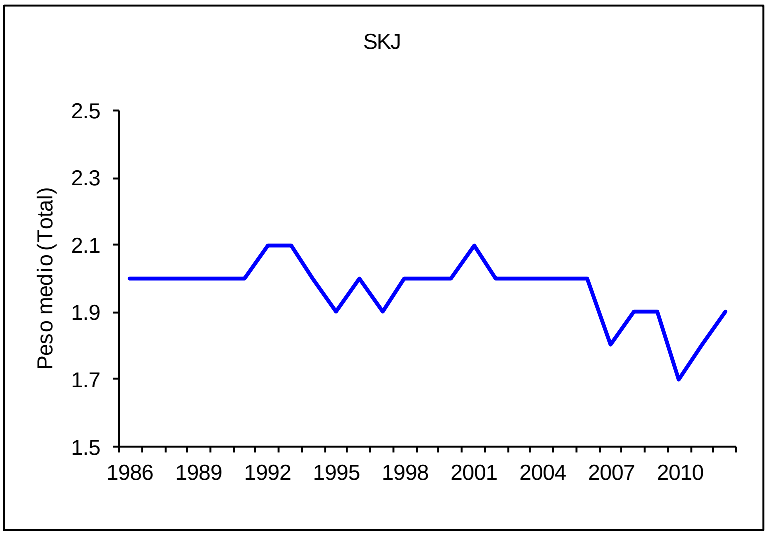

Figura 25. Pesos medios anuales de listado, capturado por la flota española de cerco.

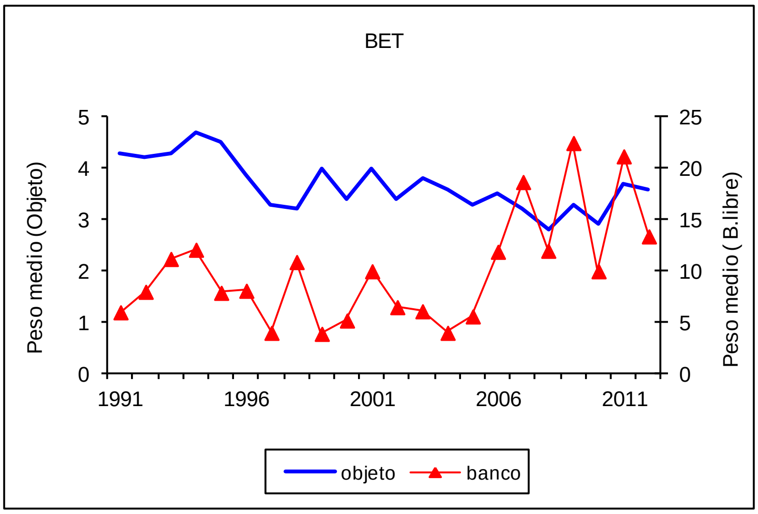

Figura 26. Pesos medios anuales de patudo para objeto y banco libre, capturado por la flota española de cerco.

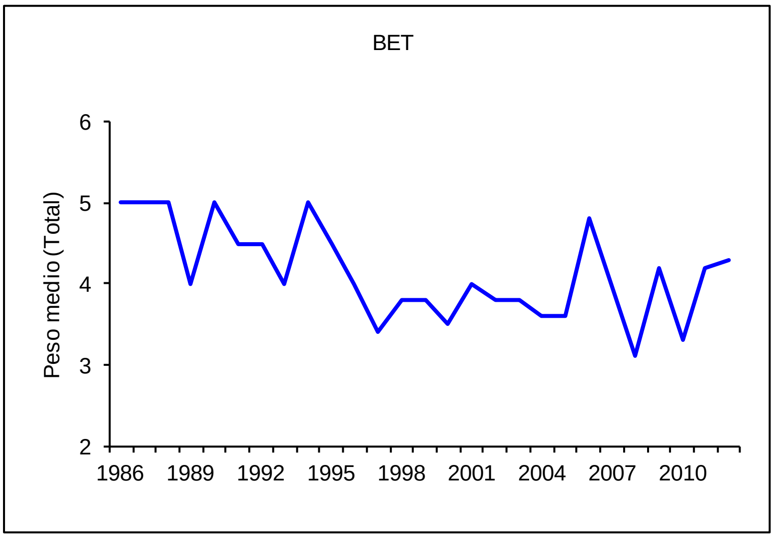

Figura 27. Pesos medios anuales de patudo, capturado por la flota española de cerco.

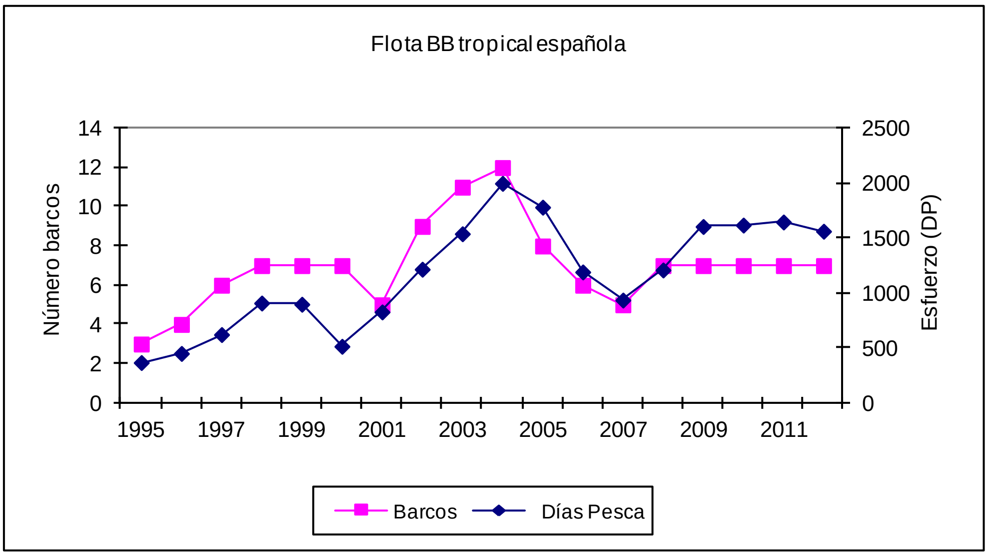

Figura 28. Número de barcos y esfuerzo, en días pesca, de la flota de cebo tropical española, con base en Dakar.

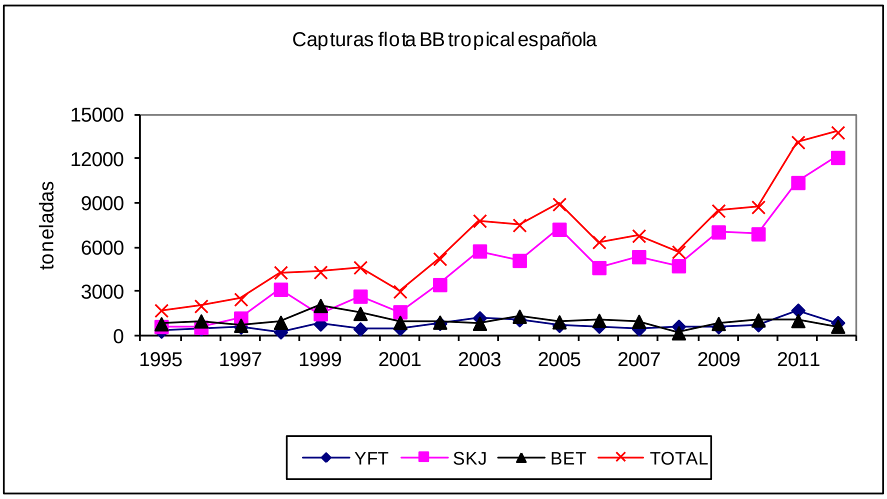

Figura 29. Captura anuales, por especie, de la flota de cebo tropical española, con base en Dakar.

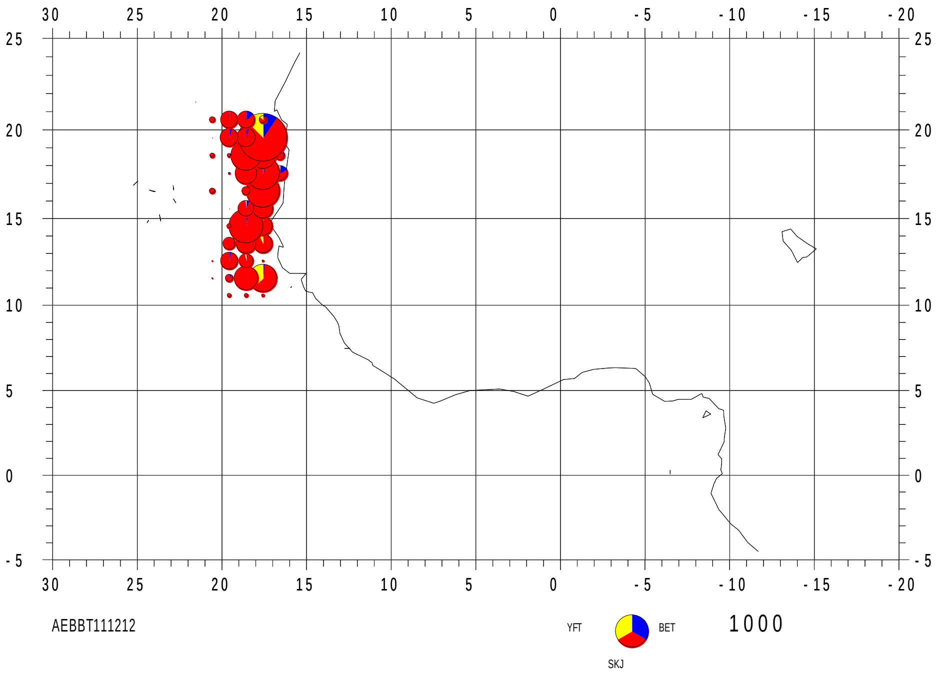

Figura 30. Distribución de las capturas de rabil, listado y patudo de la flota española atunera de cebo tropical en 2012.

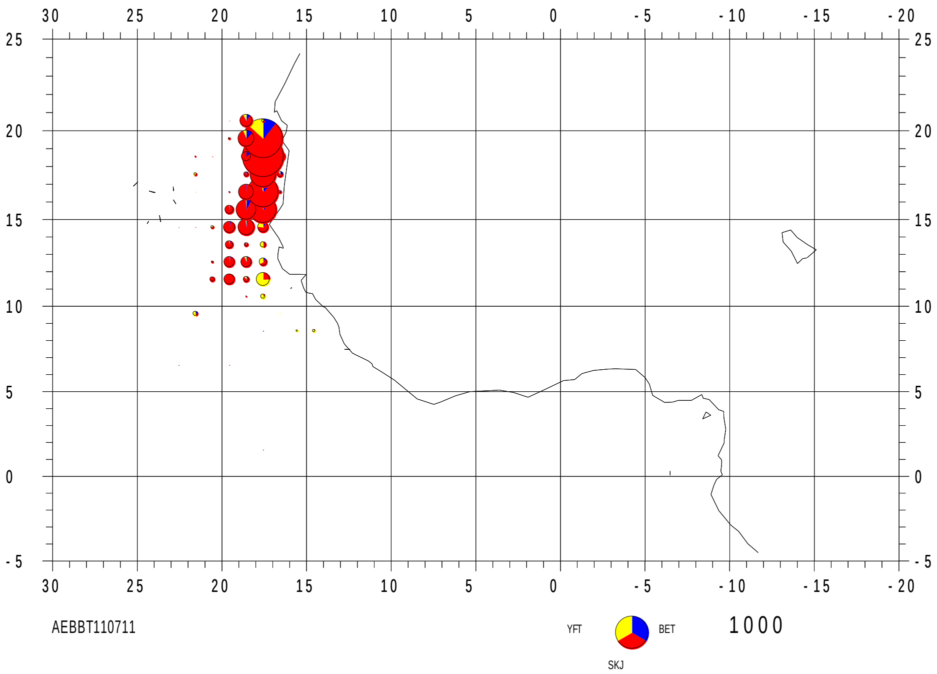

Figura 31. Distribución de las capturas de rabil, listado y patudo de la flota española atunera de cebo tropical para el periodo 2007 - 2011.

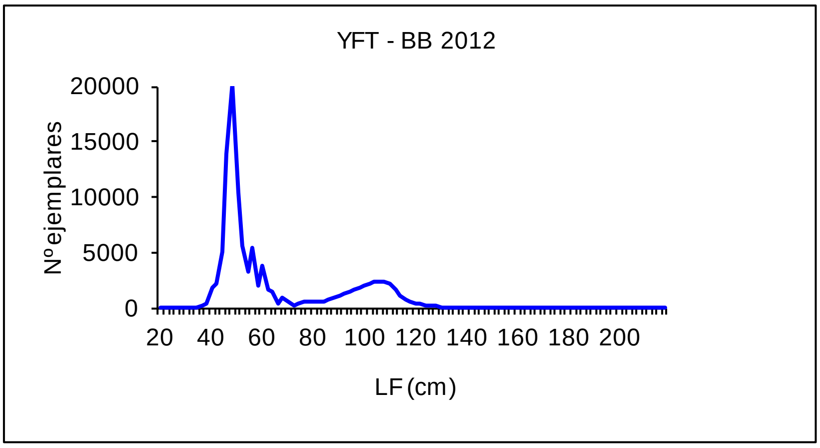

Figura 32. Distribución de tallas del rabil capturado por la flota española de cebo vivo tropical.

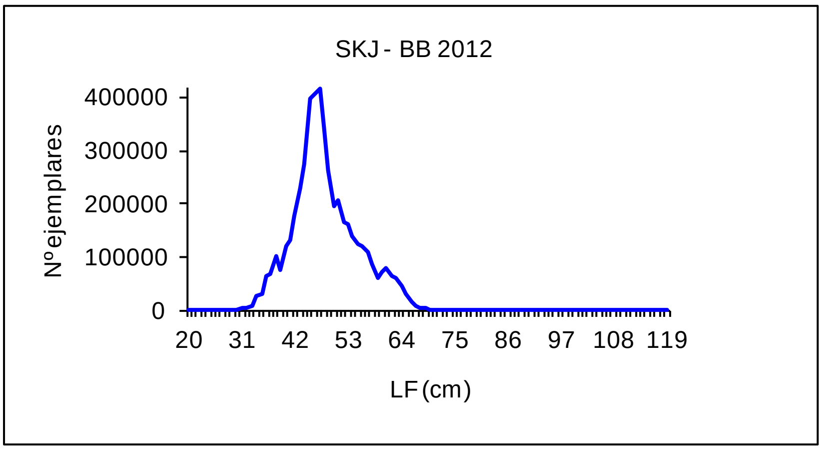

Figura 33. Distribución de tallas de listado capturado la flota española de cebo vivo tropical.

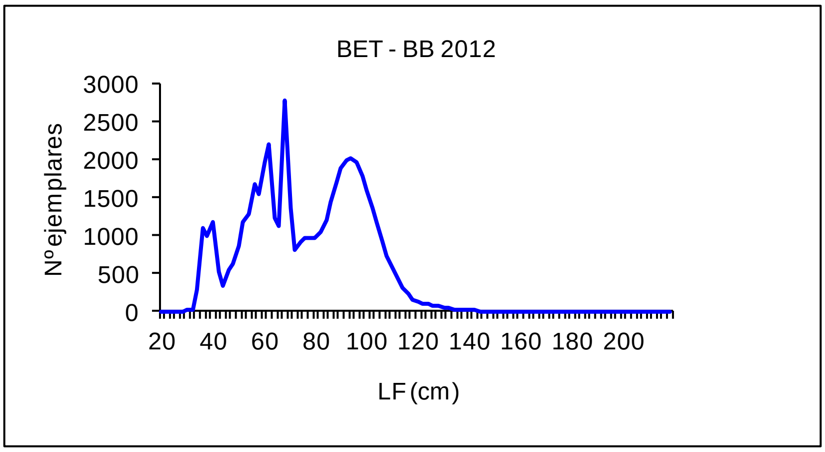

Figura 34. Distribución de tallas de patudo capturado la flota española de cebo vivo tropical.

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STATISTICS OF THE EUROPEAN AND ASSOCIATED PURSE SEINE AND BAITBOAT FLEETS, IN THE ATLANTIC OCEAN

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SUMMARY

This document presents a summarized statistical balance of the European and assimilated purse seine and baitboat fleet from 1991 to 2012. The document presents indications on fleet characteristics (type of fishery by number category), fishing effort by type and vessel size category, number of 1º square visited by the fleet by year during the period, catches, effort and PUE by species for purse seine and baitboat, as well as the average individual weight by species and by gear. Fishing maps are also presented indicating fleet deployment in the Atlantic, as well as the time-area distribution of European and assimilated purse seine catches in 2012 compared to the average 2007-2011 scenario.

RÉSUMÉ

Ce document récapitule le solde statistique des flottilles de senneurs et de canneurs européens et assimilés de 1991 à 2012. Le document présente des indications sur les caractéristiques des flottilles (type de pêcherie par catégorie numérique), l'effort de pêche par type et catégorie de taille des navires, nombre de carrés de 1º visités par la flottille par année pendant la période, les prises, l'effort et la CPUE par espèce pour les senneurs et les canneurs, ainsi que le poids moyen individuel par espèce et par engin. Des cartes de pêche sont également présentées indiquant le déploiement des flottilles dans l'Atlantique, ainsi que la distribution spatio-temporelle des prises des senneurs européens et assimilés en 2012 par rapport au scénario moyen de 2007-2011.

RESUMEN

En este documento se presenta un resumen de la actividad de la flota europea y asimilada de cerco y cebo vivo entre 1991-2012. El documento contiene algunas características de la flota (número por tipo de pesca y categoría), el esfuerzo pesquero por tipos y categoría de tamaño del buque, número de cuadrículas de 1º x 1º visitadas por la flota, las capturas, el esfuerzo y CPUE por especies para cerco y cebo vivo, así como el peso promedio por especie y tipo de pesca. También se muestran mapas de pesca indicando el despliegue de la flota en el Atlántico, así como la distribución espacio-temporal de las capturas de la flota de cerco europea y asimilada en 2012 en comparación con el promedio de 2007-2011.

KEYWORDS

Tuna fishery, yellowfin, skipjack, bigeye, baitboats, purse seiners, catch/effort, species composition, size composition.

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Table 1. Catches by species (tones) of European and associated purse-seine fleet.

			ALL			
Year	*YFT*	*SKJ*	*BET*	*ALB*	*Others*	*Total*
1991	92476	125536	14188	416	1735	234351
1992	96706	87244	18230	2518	1255	205952
1993	90102	124875	30857	1450	1246	248530
1994	88062	105633	32379	1079	2239	229391
1995	84684	99208	25096	412	2302	211703
1996	82476	83928	25006	258	3799	195468
1997	68311	60204	15918	118	2733	147284
1998	73339	56439	12622	434	3065	145898
1999	58248	76845	15593	264	2004	152955
2000	64190	64493	13698	32	1741	144154
2001	77098	60918	14030	24	2460	154531
2002	75207	48068	14282	39	1008	138604
2003	66043	73424	14303	308	1561	155639
2004	53206	77033	10816	19	1784	142858
2005	49326	58509	9685	533	1528	119581
2006	49892	47556	10919	441	1216	110024
2007	43183	54178	10794	45	1972	110172
2008	62576	58269	12603	76	1802	135326
2009	67103	62960	16790	149	2578	149581
2010	62071	75957	19090	303	2329	159749
2011	51577	84445	21368	146	1967	159503
2012	56949	95341	17681	360	3112	173443

Table 2. Catches by species (tones), on logs, of European and associated purse-seine fleet.

			Objects			
Year	*YFT*	*SKJ*	*BET*	*ALB*	*Others*	*TOTAL*
1991	15775	82330	12193	6	970	111274
1992	18121	65424	14660	24	695	98925
1993	19653	76822	22215	6	798	119495
1994	23400	67023	26478	0	1515	118416
1995	21245	75704	21598	5	1937	120490
1996	20246	71203	21860	0	3053	116362
1997	12378	38590	13280	0	2227	66475
1998	10869	29833	10383	0	1904	52989
1999	12360	39971	12695	181	985	66192
2000	12885	45054	11164	0	1487	70590
2001	11665	45584	11611	1	2222	71084
2002	11526	36947	11262	3	881	60620
2003	12660	43940	11198	101	1014	68914
2004	11913	52419	9086	0	1267	74685
2005	10818	48329	7827	28	1442	68443
2006	10328	40887	6479	1	1148	58843
2007	9921	50364	7597	2	1956	69841
2008	14256	51671	10335	5	1639	77906
2009	12191	58190	12744	1	2365	85490
2010	15890	68124	14960	13	2222	101208
2011	13260	77429	17778	16	1782	110266
2012	13357	88983	13458	15	2822	118635

Table 3. Catches by species (tones), on free schools, of European and associated purse-seine fleet.

			Free School			
Year	*YFT*	*SKJ*	*BET*	*ALB*	*Others*	*TOTAL*
1991	76701	43206	1995	410	764	123077
1992	78585	21819	3569	2494	560	107027
1993	70448	48053	8642	1444	448	129035
1994	64662	38610	5901	1079	724	110975
1995	63439	23504	3497	407	365	91213
1996	62230	12725	3146	258	746	79106
1997	55933	21615	2638	118	505	80809
1998	62470	26605	2239	434	1161	92909
1999	45888	36874	2898	83	1020	86764
2000	51305	19439	2534	32	254	73564
2001	65433	15334	2419	23	238	83446
2002	63681	11121	3020	36	126	77984
2003	53382	29483	3105	207	547	86725
2004	41294	24614	1730	19	517	68173
2005	38508	10180	1859	505	86	51138
2006	39564	6669	4440	440	69	51181
2007	33261	3814	3197	43	15	40331
2008	48320	6598	2268	71	163	57420
2009	54912	4771	4047	148	213	64091
2010	46181	7833	4130	291	107	58541
2011	38316	7016	3590	130	185	49237
2012	43592	6358	4223	345	290	54808

Table 4. Purse seine number by size categories and carrying capacity of the European and associated fleet.

Year	*50-400*	*401-600*	*601-800*	*801-1200*	*1201-2000*	> 2000	*Total*	*C. capacity*
1991	5	28	11	18	8	1	**71**	41978
1992	3	27	9	16	9	1	**65**	44296
1993	3	24	10	16	10	1	**64**	41227
1994	3	24	9	14	8	1	**59**	41122
1995	1	24	9	14	7	0	**55**	38196
1996	2	23	9	13	7	0	**54**	35775
1997	1	23	9	13	6	0	**52**	30907
1998	1	20	7	10	5	1	**44**	29988
1999	1	21	5	9	5	0	**41**	25877
2000	1	20	7	10	3	0	**41**	27385
2001	1	18	7	12	6	0	**44**	30714
2002	1	19	5	10	6	0	**41**	25036
2003	1	16	3	11	4	0	**35**	25681
2004	1	14	3	11	5	0	**34**	25311
2005	0	10	2	10	5	0	**27**	21856
2006	0	10	2	7	5	0	**24**	17574
2007	0	9	3	8	7	0	**27**	19104
2008	0	9	4	9	9	0	**31**	23211
2009	0	7	4	14	11	0	**36**	30415
2010	0	6	4	13	11	0	**34**	32213
2011	0	6	4	13	10	0	**33**	31417
2012	0	5	4	13	10	0	**32**	29557

Table 5. Purse seine number from the European and associated fleet according to their flag.

Flag	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Neth. Antilles						3	3	3	3	3	3	2	3	3		1	1	1	3	3	3	4
Belize								1		1	1								2	1	1	1
Cape Verde															2	2	2	2	2	2	2	2
El Salvador											1											
Spain	37	37	30	30	24	24	20	19	19	19	17	16	15	15	10	8	13	15	16	15	15	14
France	23	17	18	18	17	16	19	15	15	14	17	17	14	12	9	7	5	7	10	10	9	9
Ghana							1	1	1	1	1	1	1	1	1	1	1	1	1			
Guatemala													1	2	2	2	2	2	1	1	1	1
Guina Conakry					2	2	2															
Honduras			1																			
Italy	1	1																				
Liberia				2	1																	
Malaysia							1															
Malta	1	1	1																			
Morocco	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1						
Norway	1																					
Panama	7	5	7	7	6	5	2	1	1	1	1	1			3	3	3	3	2	3	2	2
Seychelles					1						1	1										
St Vincent	2	4	4	2	3	2	2	3	1	3	3											
Vanuatu		1	2	2	2	2	2	1														
Venezuela												2	1									
Total PS	**73**	**67**	**64**	**62**	**57**	**55**	**53**	**45**	**41**	**43**	**46**	**41**	**36**	**34**	**28**	**25**	**27**	**31**	**37**	**35**	**33**	**33**

Table 6. Carrying capacity and fishing efforts (raw fishing days and searching days) of the European and associated purse seine fleet.

Year	C.Capaciy	F. days	S. days
1991	41978	15636	13712
1992	44296	17459	15891
1993	41227	16428	14677
1994	41122	15905	14233
1995	38196	14789	13089
1996	35775	14672	13118
1997	30907	12784	11554
1998	29988	12594	11223
1999	25877	11732	10579
2000	27385	10579	9396
2001	30714	11346	10123
2002	25036	9826	8818
2003	25681	8964	7741
2004	25311	8522	7557
2005	21856	7115	6259
2006	17574	5727	5036
2007	19104	6130	5385
2008	23211	7086	6098
2009	30425	8850	7623
2010	32213	9262	8257
2011	31417	8956	7567
2012	29557	8556	7182

Table 7. Catches by species (tones) of European and associated bait boat fleet.

Year	*YFT*	*SKJ*	*BET*	*ALB*	*Others*	*TOTAL*
1991	4986	2011	2831	0	30	9858
1992	3460	1955	2305	0	2	7722
1993	3147	3059	2741	0	3	8951
1994	3474	3534	3269	0	21	10299
1995	2298	3772	3188	0	117	9376
1996	2313	2703	3766	0	0	8782
1997	1878	6071	3005	0	227	11181
1998	852	10019	3853	0	24	14748
1999	3179	6714	7236	0	803	17931
2000	1470	7765	5956	0	342	15534
2001	1694	7882	4969	0	37	14583
2002	3495	9167	2721	0	28	15411
2003	2773	10356	2512	0	49	15691
2004	2887	9706	2646	0	51	15290
2005	2146	15042	2328	4	162	19682
2006	2187	9012	2674	0	1319	15191
2007	1658	11382	2225	0	1553	16819
2008	1586	10059	1431	0	1353	14428
2009	2101	12693	2084	0	90	16968
2010	2266	10256	2040	0	202	14764
2011	3324	15949	1458	0	301	21032
2012	2793	17721	1030	0	223	21767

Table 8. Bait boats number by size categories and carrying capacity of the European and associated fleet.

Year	*Bait boat* 50-400	*Total*	*Carrying capacity*
1994	14	14	350
1995	14	14	367
1996	14	14	332
1997	16	16	448
1998	18	18	480
1999	19	19	606
2000	24	24	770
2001	15	15	747
2002	19	19	765
2003	24	24	693
2004	22	22	815
2005	18	18	874
2006	17	17	908
2007	16	16	856
2008	18	18	776
2009	17	17	801
2010	14	14	642
2011	14	14	1461
2012	14	14	1463

Table 9. Bait boats number from the European and associated fleet according to their flag.

Pavillon	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Antilles Holl.									1	5	3	2	3	2	2							
Cap Vert		1	1	1	1	1	1	1	1													
Espagne					3	4	6	7	7	7	5	9	11	12	9	6	5	7	7	7	7	7
France	9	8	9	7	8	7	7	7	5	5	5	5	5	5	4	4	4	4	3	1	1	1
Panama									1	1												
Sénégal	1		1	2	3	1	2	3	3	6	2	2	4	3	6		7	7	7	6	6	6
St Vincent						1	1	2	2	2	1	1	1									
Total	**10**	**9**	**11**	**10**	**15**	**14**	**17**	**20**	**20**	**26**	**16**	**19**	**24**	**22**	**21**	**10**	**16**	**18**	**17**	**14**	**14**	**14**

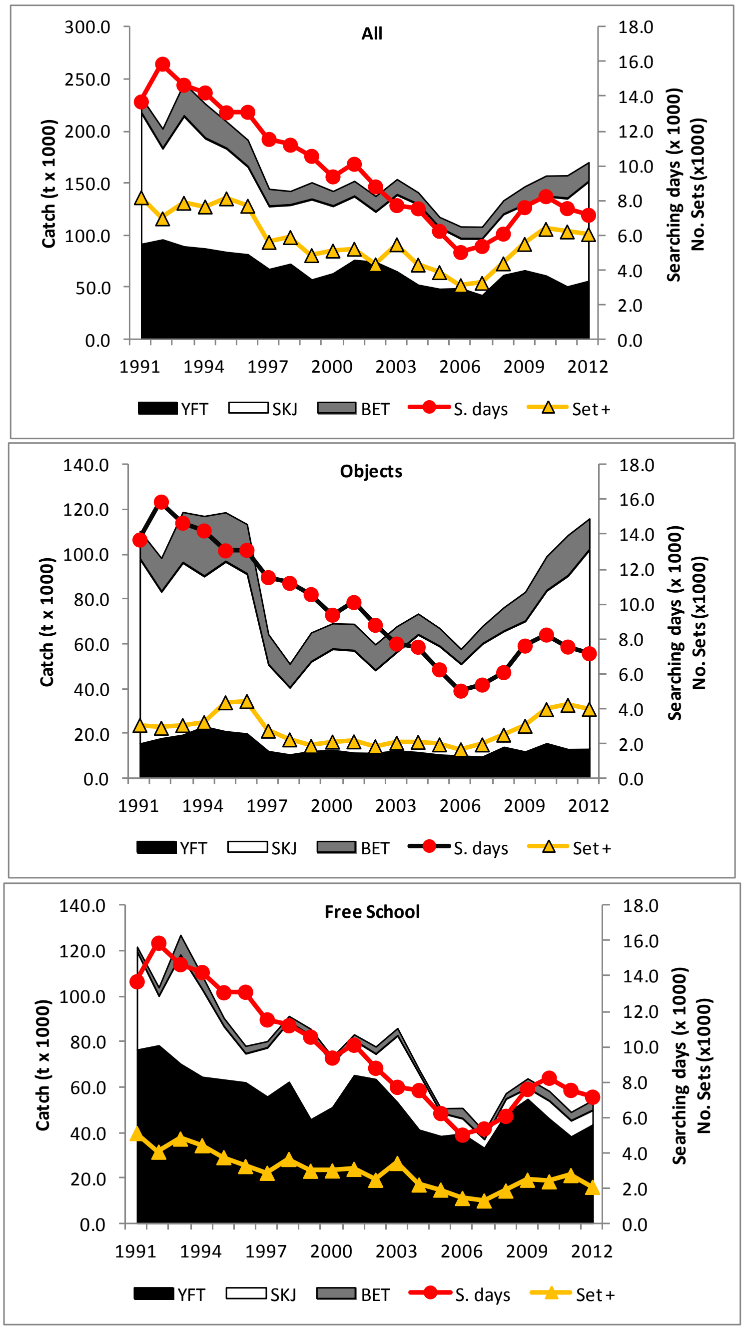

Figure 1. Catches by species and fishing effort in searching days of the European and associated purse-seine fleet according to their fishing mode: combined (top), logs (middles) and free schools (bottom).

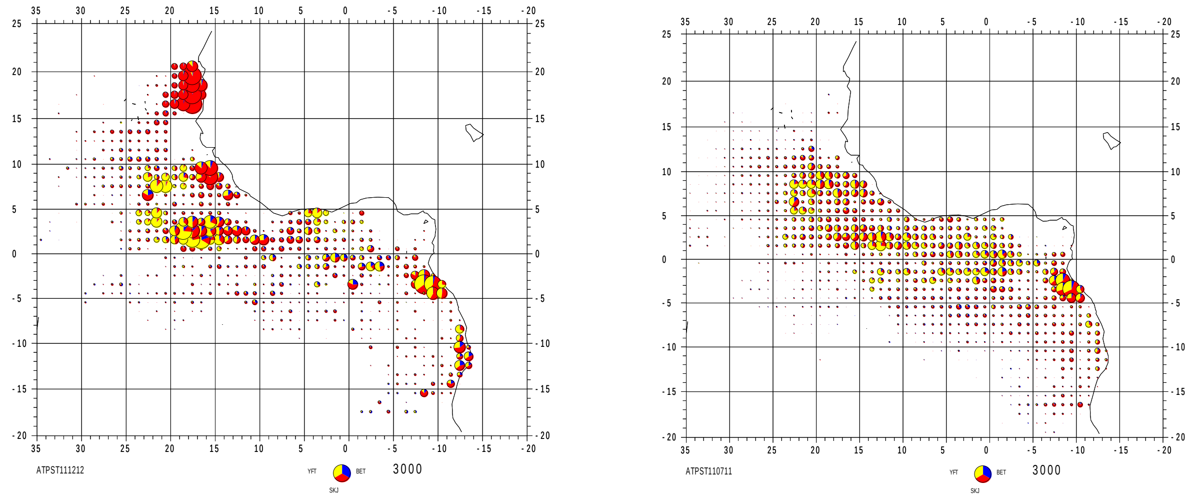

Figure 2. Distribution of the catches by species of the European and associated purse-seine fleet in 2012 (left) and on average over the 2007-2011period (right).

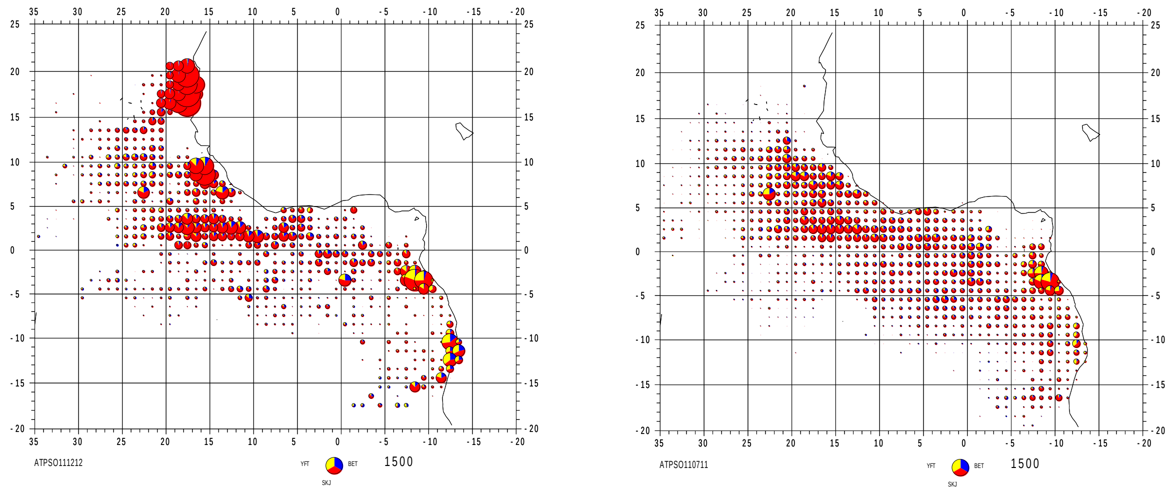

Figure 3. Distribution of the catches by species of the European and associated purse-seine fleet, on log schools, in 2012 (left) and on average over the 2007-2011period (right).

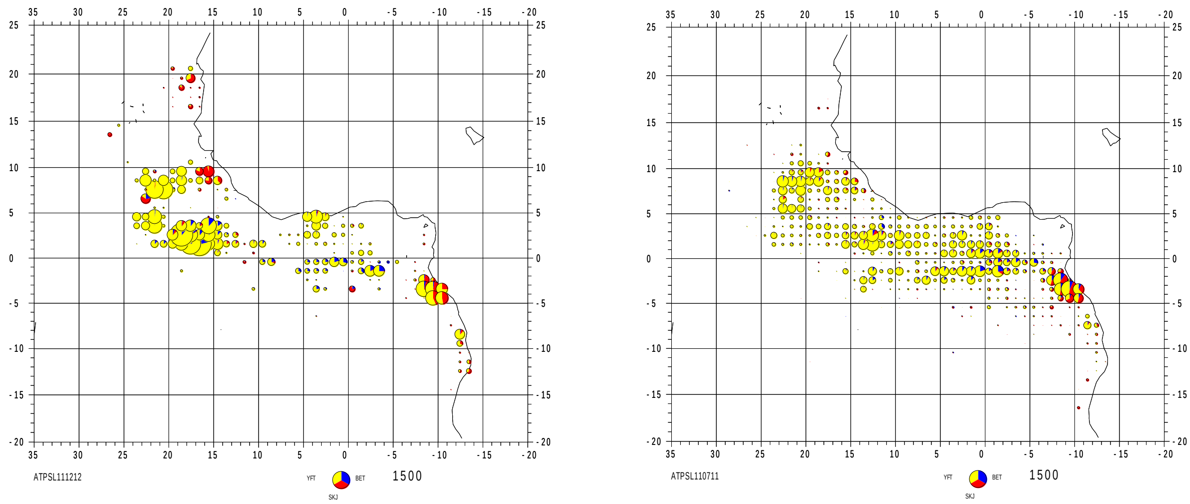

Figure 4. Distribution of the catches by species of the European and associated purse-seine fleet, on free schools, in 2012 (left) and on average over the 2007-2011period (right).

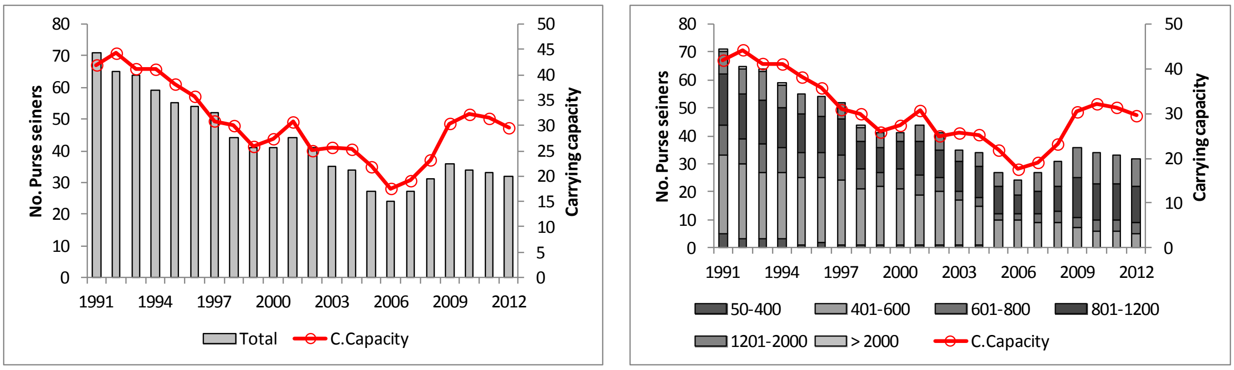

Figure 5. Boats number (left) and boats number per TJB category (right) and carrying capacity of European and associated purse-seine fleet.

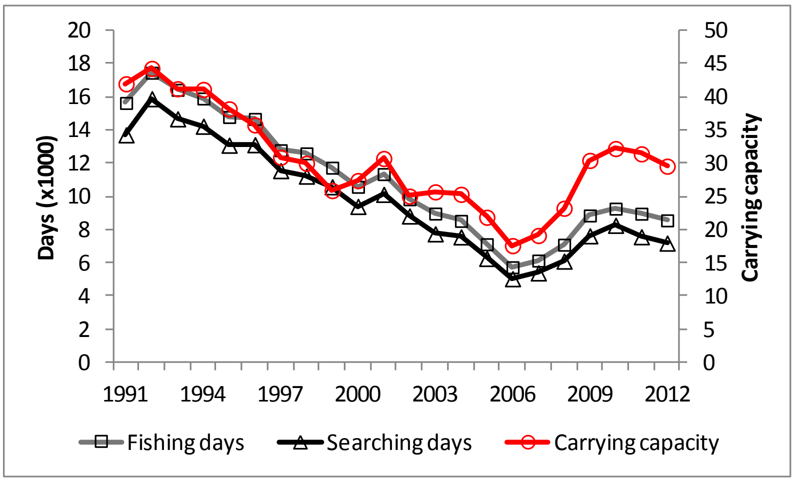

Figure 6. Fishing effort of European and associated purse-seine fleet in number of fishing days, searching days and carrying capacity.

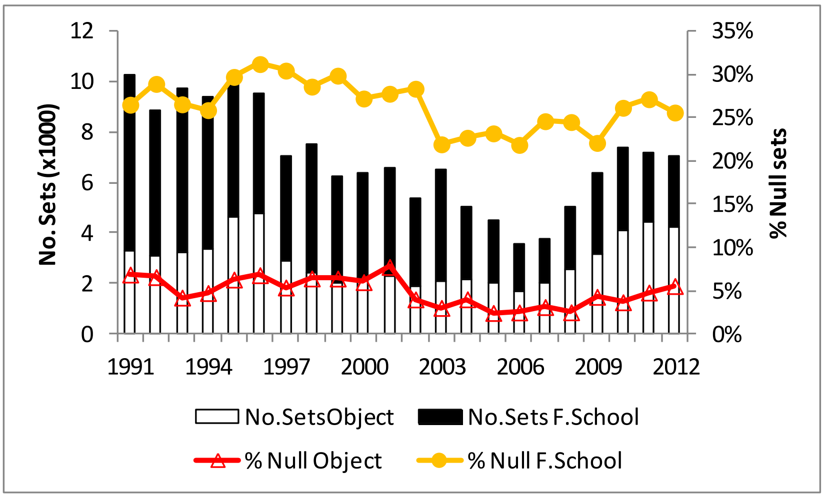

Figure 7. Number of sets and % of null sets according to the fishing mode.

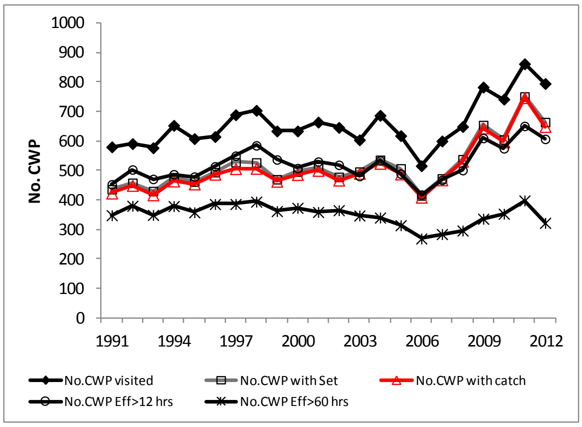

Figure 8. Explored CWP number squares according to various levels of effort.

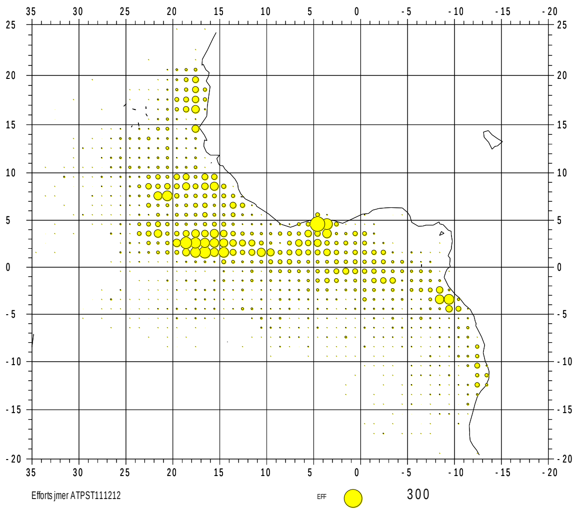

Figure 9. Distribution of the fishing effort (days at sea) of the European and associated purse-seine fleet in 2012.

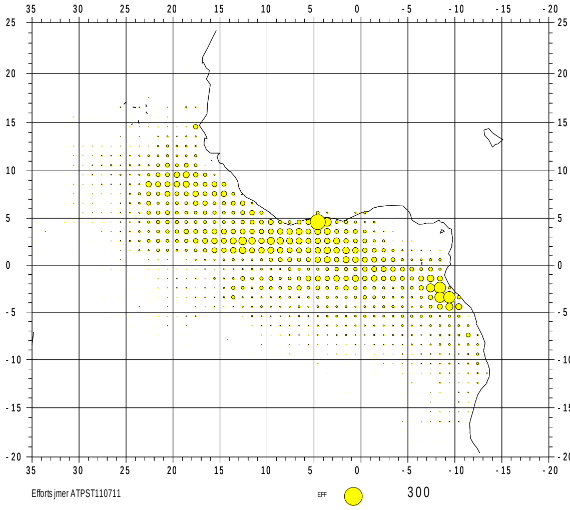

Figure 10. Distribution of the fishing effort (days at sea) of the European and associated purse-seine fleet on average over the 2007-2011 period.

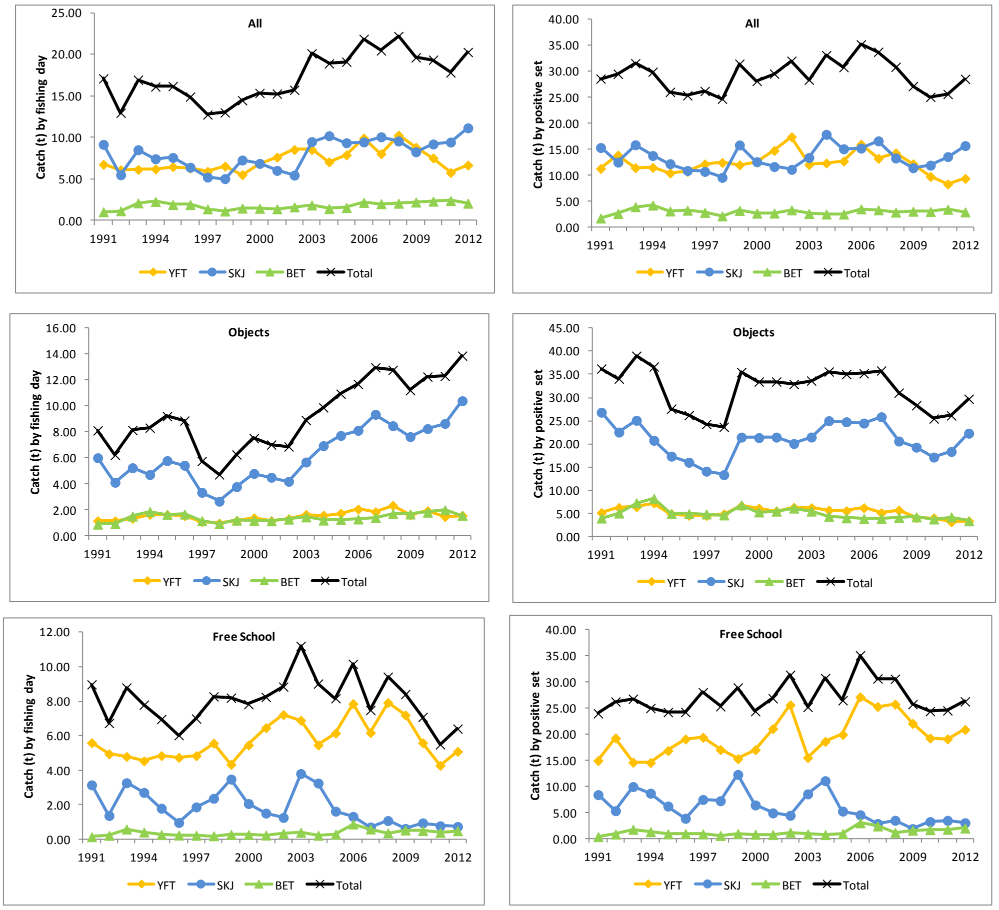

Figure 11. Catch per unit of effort of the European and associated purse-seine fleet tones per fishing days, (left) and tones per positive set (right), according their fishing mode, combined (top), logs (middle) and free schools (bottom).

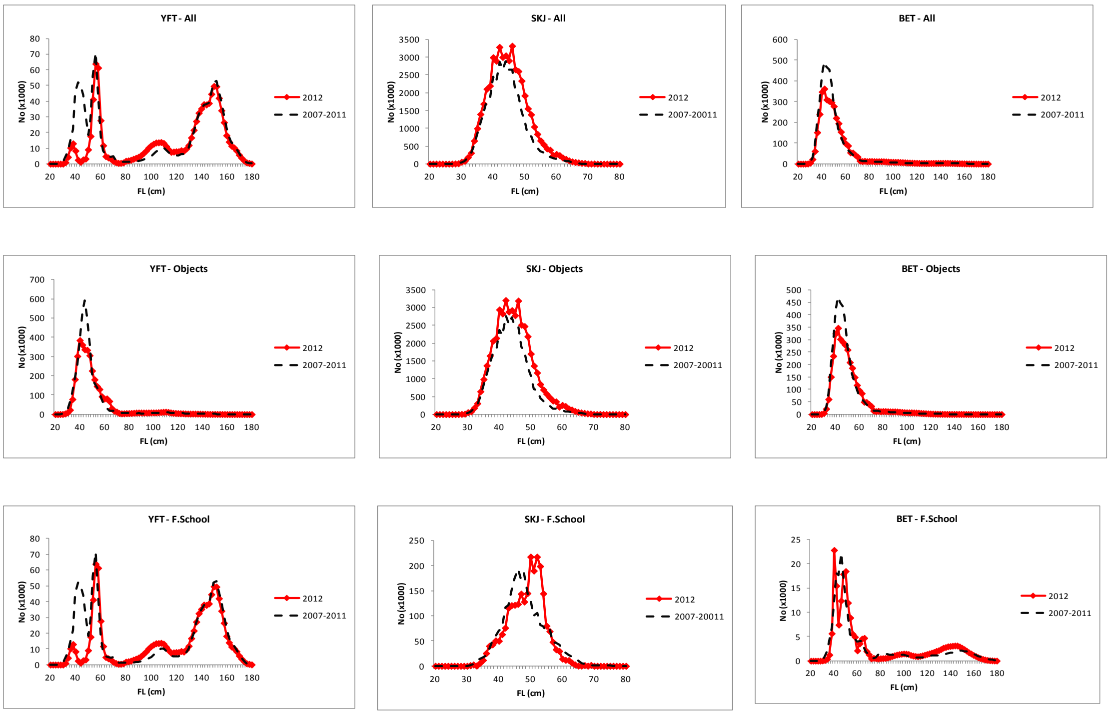

Figure 12. Size distribution of the catches by species (YFT, left; SKJ, middle; BET, right), by fishing mode (combined, top; Logs, middle; Free schools, bottom), in 2012 and on average over 2007 – 2011 period.

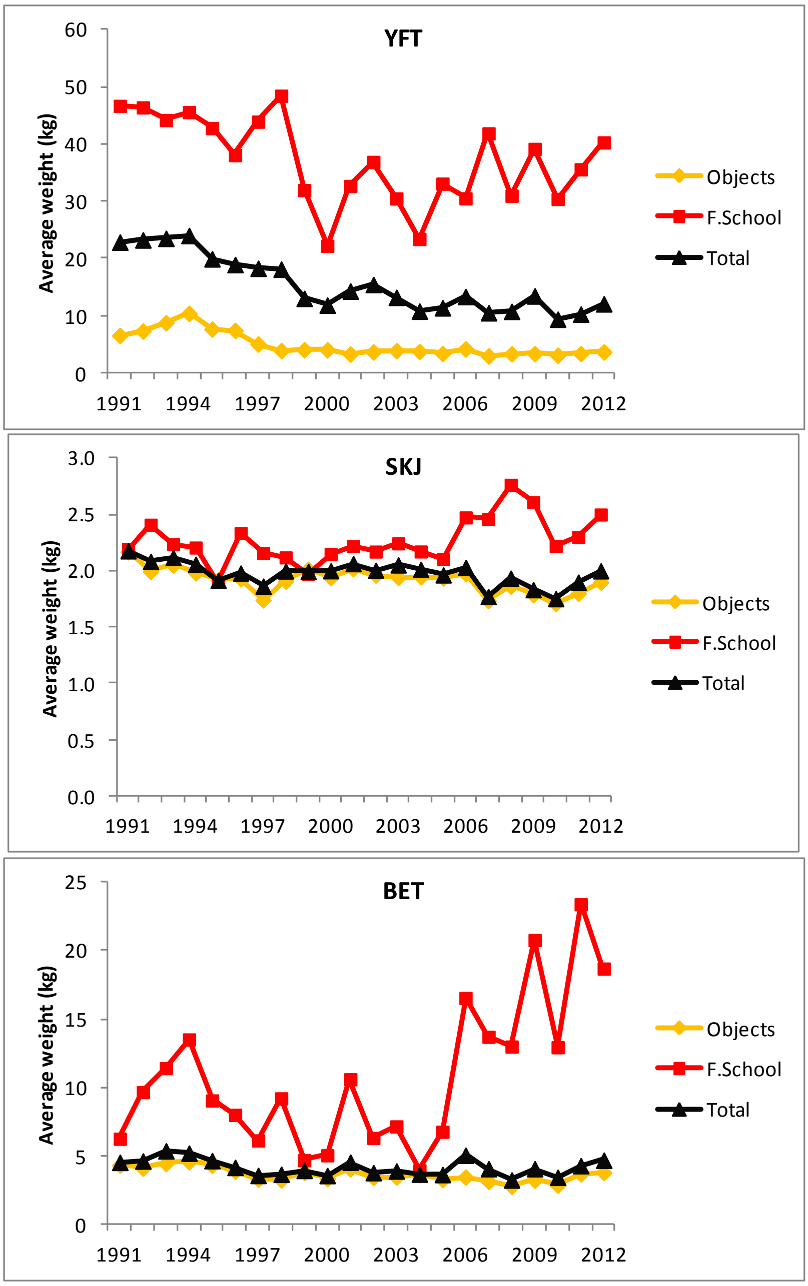

Figure 13. Average weight of the European and associated purse-seine fleet catches by species (YFT, top; SKJ, middle; BET, bottom) according to their fishing mode.

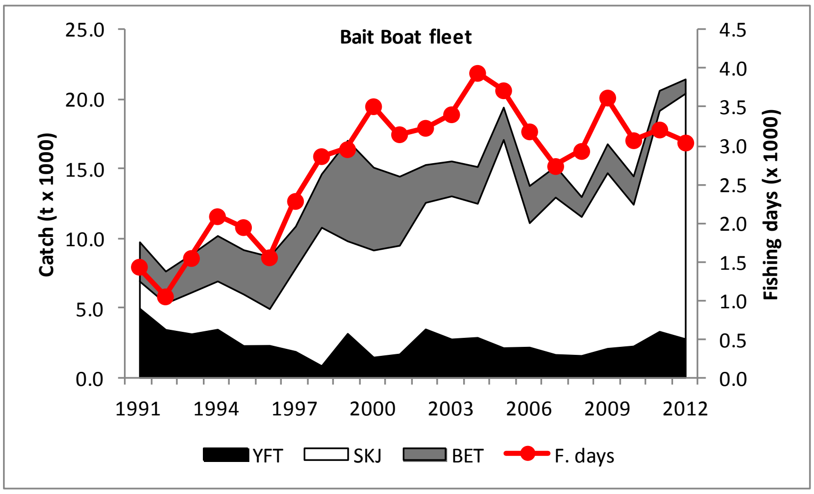

Figure 14. Catches by species and fishing effort in fishing days of the European and associated bait boat fleet.

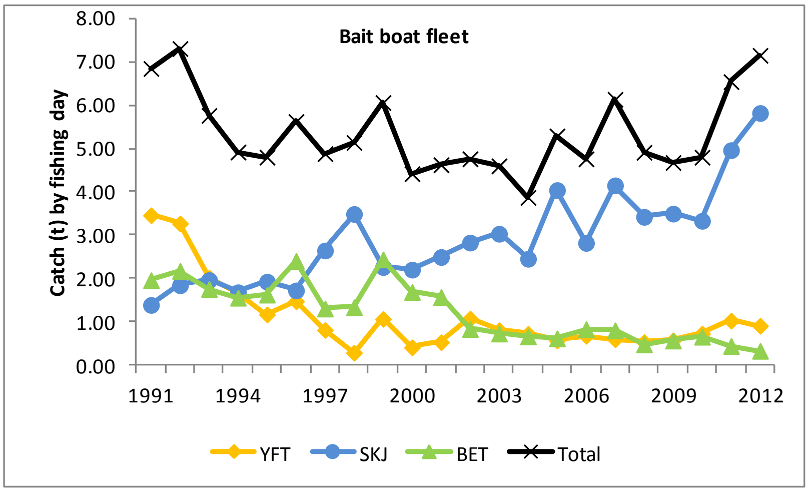

Figure 15. Catch per unit of effort of the European and associated bait boat fleet, tones per fishing days, by species.

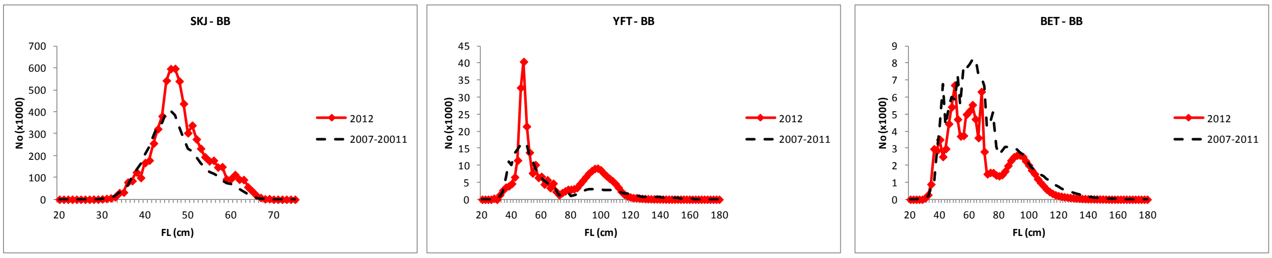

Figure 16. Size distribution of the catches by species (YFT, left; SKJ, middle; BET, right) in 2012 and on average over 2007 – 2011 period.

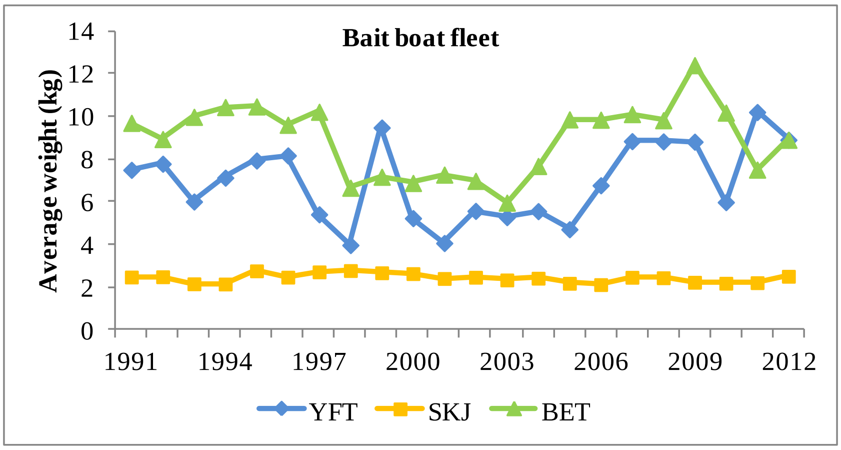

Figure 17. Average weight of the European and associated bait boat fleet catches by species.

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STATISTICS OF THE FRENCH PURSE SEINE FISHING FLEET TARGETING TROPICAL TUNAS IN THE ATLANTIC OCEAN (1991-2012)

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SUMMARY

In 2012, the French purse seine fishing fleet of the Atlantic was composed of 9 vessels of individual carrying capacity >600 t, which all represented a total carrying capacity of 9,000 t. The total cumulated nominal effort was about 2,500 and 2,000 fishing and searching days, respectively. The total number of fishing sets was about 1,900, with nearly 50% realised on schools associated with fish aggregating devices (FAD). Between 2011 and 2012, the capacity and nominal effort of the fleet increased by more than 10% while the total catches decreased by 8%. The decline in catch might be explained by the non access of the fleet to the coastal fishing grounds of Gabon which represented 25% of the fleet catch during 2010-2011 (i.e. 8,000-10,000 t). Overall, the year 2012 was characterized by a decrease in fishing sets and resulting catch on free-swimming schools (FSC) which was partly balanced by increased catches on FADs. Hence, the total catch of skipjack and bigeye remained stable during 2010-2012, i.e. about 12,600 t and 3,300 t, respectively, while the catch of yellowfin decreased by 15% between 2011 and 2012 to reach about 18,000 t. The decrease in yellowfin catch was due to a decrease in the number of sets per searching day on FSC while the catch per positive set remained constant for both fishing modes in 2012, i.e. 20.8 t set^{-1} and 3.4 t set^{-1} for FSC and FAD, respectively. For skipjack, catch per positive set in the FAD fishery decreased by 13.5% between 2011 and 2012 but remained at a level of 14 t set^{-1}, similar to the average observed during 2009-2011. By contrast, catch per positive set of skipjack on FSC steadily decreased during 1991-2012 to reach a minimum of 0.56 t set^{-1} in 2012, in relation with the absence of fishing in the Cap Lopez area where large skipjack are generally caught.

RÉSUMÉ

En 2012, la flottille de senneurs français opérant dans l'Atlantique se composait de neuf navires, chacun ayant une capacité de transport > 600 t, représentant dans leur totalité une capacité de transport de 9.000 t. L'effort nominal cumulé total s'élevait à environ 2.500 et à 2.000 jours de pêche et de recherche, respectivement. Le nombre total d'opérations de pêche s'élevait à environ 1.900, à peu près la moitié étant réalisée sur des bancs associés à des dispositifs de concentration des poissons (DCP). Entre 2011 et 2012, la capacité et l'effort nominal de la flottille ont augmenté de plus de 10%, tandis que les prises totales ont diminué de 8%. La chute des captures pourrait s'expliquer par le fait que la flottille n'avait pas accès aux zones de pêche côtières du Gabon, qui représentaient 25% de la capture de la flottille entre 2010 et 2011 (c.-à-d. 8.000-10.000 t). En règle générale, l'année 2012 a été caractérisée par une diminution des opérations de pêche et des prises résultantes sur bancs libres, ce qui a été en partie compensé par l'augmentation des prises sous DCP. Par conséquent, la prise totale de listao et de thon obèse est demeurée stable entre 2010 et 2012, c.-à-d. à environ 12.600 t et 3.300 t, respectivement, tandis que la prise d'albacore a baissé de 15% entre 2011 et 2012 pour atteindre environ 18.000 t. La baisse des prises d'albacore était due à la diminution du nombre d'opérations par jour de recherche sur bancs libres tandis que la capture par opération positive est demeurée inchangée pour les deux modes de pêche en 2012, c.-à-d. 20,8 t opération $^{-1}$ pour la pêche en bancs libres et 3,4 t opération^{-1} pour la pêche sous DCP. Pour le listao, la prise par opération positive dans la pêcherie opérant sous DCP a chuté de 13,5% entre 2011 et 2012, mais elle est demeurée à un niveau de 14 t opération $^{-1}$ similaire à la moyenne observée entre 2009 et 2011. En revanche, les captures de listao par opération positive en bancs libres ont diminué progressivement entre 1991 et 2012, pour atteindre un minimum de 0,56 t opération^{-1}

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en 2012 en rapport avec l'absence de la pêche dans la zone de Cap Lopez où les gros listaos sont généralement capturés.

RESUMEN

En 2012, la flota de cerco francesa del océano Atlántico estaba compuesta por nueve buques con una capacidad de transporte individual de más de >600 t, lo que supone una capacidad de transporte total de 9.000 t. El esfuerzo nominal total acumulado fue de aproximadamente 2.500 y 2.000 días de pesca y búsqueda, respectivamente. El número total de lances fue de aproximadamente 1.900, y casi el 50% se realizó sobre bancos asociados con dispositivos de concentración de peces (DCP). Entre 2011 y 2012, la capacidad y el esfuerzo nominal de la flota se incrementaron en más de un 10%, mientras que las capturas totales experimentaron un descenso del 8%. El descenso en la captura podría explicarse porque la flota no accedió a los caladeros de la costa de Gabón, donde obtuvo el 25% de su captura en el periodo 2010-2011 (a saber, 8.000-10.000 t) En general, el año 2012 se caracterizó por un descenso de las operaciones de pesca y de la captura resultante en bancos libres (FSC), que se vio equilibrada en parte por un incremento de las capturas en DCP. Por tanto, la captura de listado y patudo se mantuvo estable durante 2010-2012, a saber, aproximadamente 12.600 t y 3.300 t, respectivamente, mientras que la captura de rabil descendió un 15% entre 2011 y 2011, situándose en aproximadamente 18.000 t. El descenso en la captura de rabil se debió a un descenso en el número de lances por día de búsqueda en bancos libres, mientras que la captura por lance positivo se mantuvo constante para los dos tipos de pesca en 2012, a saber, 20,8 t lance^{-1} y 3,4 t lance^{-1} para bancos libres y DCP, respectivamente. Para el listado, la captura por lance positivo en la pesquería con DCP experimentó un descenso del 13,5% entre 2011 y 2012, pero se mantuvo en un nivel de 14 t lance^{-1}, similar al promedio observado durante el periodo 2009-2011. Por el contrario, la captura de listado por lance positivo en bancos libres experimentó un marcado descenso en el periodo 1991-2012 llegando a un mínimo de 0,56 t por lance^{-1} en 2012, relacionado con la ausencia de pesca en la zona de Cabo López, donde se suelen capturar grandes listados.

KEYWORDS

Catch statistics, FAD, Free-swimming school, High seas fisheries, Purse seining

1 Introduction

French purse seiners operating in the Atlantic Ocean target yellowfin (*Thunnus albacares*), skipjack (*Katsuwonus pelamis*), and bigeye tuna (*Thunnus obesus*) through two major fishing modes that result in different species and size composition of the catch: fish aggregating device-associated (FAD) and free-swimming schools (FSC). Statistical data for the French purse seine fishing fleet have been collected by the ``Institut de Recherche pour le Développement" (IRD) in collaboration with the Centre de Recherches Océanologiques (CRO) in Ivory Coast, and the Centre de Recherches Océanographiques de Dakar-Thiaroye (CRODT), Sénégal since the early 1980s. The fleet activities are described through a suite of fisheries indicators that provide information on fishing capacity, effort, catch, and catch rates for the principal market tropical tunas, with a particular focus on the year 2012.

2 Fishing capacity and effort

In 2012, a total of 9 French purse seiners operated in the eastern Atlantic Ocean (**Figure 1**). The fleet was composed of 2 vessels of carrying capacity (CC) of 600-800 t, 5 vessels of CC 800-1200 t, and 2 vessels of CC >1,200 t (Table **1**). The total capacity, weighted by the months of activity for each vessel, increased by 13% between 2011 and 2012 and reached about 13,000 m^3, corresponding to 9,000 t of fish hold volume. The increase in CC was due to the arrival of 2 purse seiners from the Indian Ocean while 2 smaller and older vessels (i.e. >30 years) left the fleet in 2011.

The total nominal effort in 2012 was about 2,500 and 2,000 fishing and searching days, respectively (**Figure 2** and **Table 2**). The effort increased by more than 12% between 2011 and 2012 in relation with the increase in fishing capacity. The effort was mainly concentrated between the equator and 10°N, particularly between 10°W-20°W and off the coasts of Ivory Coast (**Figure 3**). Compared to previous years, no fishing occurred in 2012 during the months of May-September in the Cap Lopez area, i.e. within the exclusive economic zone of Gabon, due to the absence of EU Fisheries Partnership Agreement. To face up with the reduction in fishing grounds, the fleet allocated some effort south of 5°S, along the coasts of Angola. Despite the overall increased effort between 2011 and 2012 and fishing activities off Angola, the fleet appeared more concentrated in space in 2012, i.e. a total of 239 1°x1° squares with some effort in 2012 vs. 257 in 2011 (**Table 3**).

While the effort increased by more than 10% between 2011 and 2012, the total number of fishing sets was very similar, i.e. about 2,000 (**Figure 5**). There was however a strong change in the underlying fishing characteristics since the number of FAD sets increased by 40% while the FSC sets decreased by 25% between 2011 and 2012. The reduction in FSC sets might be partly explained by the non access to the Cap Lopez area where fishing on free-swimming schools represented more than 45% of the sets during 2010-2011. The overall increase in FAD sets might also result from an effect of the arrival of the 2 large purse seiners from the Indian Ocean better equipped for FAD-fishing as well as from a more general fishing strategy more oriented toward FAD-fishing in relation with the high sale price for skipjack in 2012. Consequently, the percentage of sets on FAD-associated schools reached nearly 50% in 2012, corresponding to the maximum value observed over the last 2 decades (**Table 4**).

3 Fishery production

In 2012, the total catch of the French component of the EU purse seine fleet of the Atlantic Ocean was 34,000 t, being composed of 54%, 34%, and 10% of yellowfin, skipjack, and bigeye, respectively (**Table 5**). Despite the increase in capacity and effort between 2011 and 2012, the total catch decreased by about 8% (**Figure 6**). The decrease was mainly due to the decrease in catch on FSC by 25% while the catch on FADs increased by 25% in the mean time (**Figure 7**). Overall, the total catch of skipjack and bigeye remained stable during 2010-2012, i.e. about 12,600 t and 3,300 t, respectively, while the catch of yellowfin decreased by 15% between 2011 and 2012 to reach about 18,000 t. The decrease in yellowfin catch was due to a decrease in the number of sets per searching day on FSC in 2012 (**Figure 11b**) while the catch per positive set remained constant for both fishing modes, i.e. 20.8 t set^{-1} and 3.4 t set^{-1} for FSC and FAD, respectively (**Figure 11c-d**). The mean catch of yellowfin in the FSC catch increased from about 30 kg in 2010-2012 to nearly 50 kg in 2012 due to the major decrease in the number of small yellowfin caught on free-swimming schools in 2012 (**Figure 15a**).

For skipjack, catch per positive set in the FAD fishery decreased by 13.5% between 2011 and 2012 but remained at a level of 14 t set-1, similar to the average observed during 2009-2011 (**Figure 11c**). By contrast, catch per positive set of skipjack on FSC steadily decreased during 1991-2012 to reach a minimum of 0.56 t set^{-1} in 2012, in relation with the absence of fishing in the Cap Lopez area where free-swimming skipjack are generally caught (**Figure 11d**). Indeed, the mean weight of skipjack in the catch decreased from 2.5 kg in 2011 to 2.1 kg in 2012 (**Figure 15b**).

While yellowfin were mainly caught on FSC (85% of the catch) and skipjack on FADs (>95%) in 2012, the catch of bigeye in the purse seine fleet resulted from both fishing modes, i.e. 60% and 40% from FAD and FSC, respectively (**Tables 6-7** and **Figure 14**). The decrease in the number of small bigeye on FSC in 2012 resulted in an increase in the mean weight of bigeye in the catch which increased to 31 kg in 2012 (**Figure 15c**). Meanwhile, bigeye caught in association with FADs increased from 3.7 kg to 4.2 kg in 2012 in relation with some medium-sized individuals (about 100 cm fork length) caught on FADs, a feature rarely observed in the purse seine fishery.

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Table 1. Annual number of purse seiners by size category and total carrying capacity of the European tropical tuna purse seine fishing fleet of the Atlantic Ocean during 1991-2012. Total carrying capacity (CC) was weighted by the proportion of the year at sea (in months).

Year	*50-400*	*401-600*	*601-800*	*801-1200*	*1201-2000*	*>2000*	*Total*	*CC*
1991	2	9	6	6	0	0	23	11850
1992	1	8	2	6	0	0	17	11457
1993	1	8	3	6	0	0	18	11870
1994	1	8	3	6	0	0	18	12121
1995	0	10	2	5	0	0	17	10863
1996	0	9	2	5	0	0	16	11243
1997	0	10	2	5	2	0	19	11331
1998	0	7	2	6	0	0	15	11071
1999	0	8	2	5	0	0	15	10538
2000	0	7	2	5	0	0	14	10248
2001	0	7	2	7	1	0	17	11314
2002	0	8	3	5	1	0	17	9601
2003	0	8	1	5	0	0	14	9610
2004	0	6	1	5	0	0	12	8345
2005	0	4	0	5	0	0	9	6980
2006	0	4	0	3	0	0	7	4040
2007	0	3	0	2	0	0	5	3581
2008	0	3	2	2	0	0	7	3678
2009	0	1	2	4	3	0	10	6876
2010	0	1	2	4	3	0	10	8846
2011	0	1	2	4	2	0	9	7945
2012	0	0	2	5	2	0	9	8986

Table 2. Annual nominal fishing effort of the French purse seine fishing fleet expressed in fishing and searching days during 1991-2012. Searching days was derived from the total time spent at sea corrected for periods of damage, route towards port, and purse seine operation.

Year	*Fishing days*	*Searching days*
1991	4843	4193
1992	4568	4069
1993	4576	3969
1994	4815	4225
1995	4293	3717
1996	4550	3910
1997	4300	3829
1998	4361	3837
1999	3933	3434
2000	3898	3419
2001	4049	3590
2002	3364	2955
2003	3360	2837
2004	2855	2469
2005	2274	1973
2006	1388	1189
2007	1278	1126
2008	1263	1052
2009	2019	1693
2010	2549	2110
2011	2214	1821
2012	2474	2079

Table 3. Annual number of 1-degree squares explored by the French purse seine fishing fleet during 1991-2012. #sets indicates squares where a least 1 fishing set was made.

Year	*TOTAL*	*#sets*	*Catch >0*	*Effort > 1 d*	*Effort > 5 d*
1991	389	292	272	313	213
1992	423	293	287	339	215
1993	374	270	260	296	192
1994	420	337	334	358	256
1995	405	307	299	329	200
1996	391	302	291	325	209
1997	464	334	295	373	220
1998	466	355	332	369	214
1999	365	272	260	290	184
2000	368	289	274	299	184
2001	412	283	272	322	195
2002	360	262	249	291	185
2003	358	247	240	267	163
2004	343	254	240	259	149
2005	350	232	216	257	137
2006	264	167	161	182	85
2007	272	166	153	194	84
2008	258	156	146	161	80
2009	332	221	206	228	121
2010	325	256	241	262	142
2011	364	248	235	257	128
2012	345	245	232	239	126

Table 4. Number of positive and null sets by fishing mode made by the French purse seine fishing fleet in the Atlantic ocean during 1991-2012. FAD = Fish Aggregating Device ; FSC = Free-Swimming School.

Year	*ALL-Total*	*ALL-Positive*	*ALL-Null*	*FAD-Total*	*FAD-Positive*	*FAD-Null*	*FSC-Total*	*FSC-Positive*	*FSC-Null*	*% Log*
1991	3247	2521	726	853	772	81	2394	1749	645	26
1992	2685	2140	545	955	857	98	1730	1283	447	36
1993	3232	2650	582	1172	1116	56	2060	1534	526	36
1994	3135	2581	554	1377	1296	81	1758	1285	473	44
1995	3126	2508	618	1394	1294	100	1732	1214	518	45
1996	3519	2670	849	1347	1212	135	2172	1458	714	38
1997	2598	1908	690	816	725	91	1782	1183	599	31
1998	2889	2162	727	988	913	75	1901	1249	652	34
1999	2745	1995	750	720	653	67	2025	1342	683	26
2000	2616	1971	645	683	622	61	1933	1349	584	26
2001	2500	1904	596	630	560	70	1870	1344	526	25
2002	2209	1678	531	577	545	32	1632	1133	499	26
2003	2838	2263	575	701	662	39	2137	1601	536	25
2004	2075	1657	418	712	669	43	1363	988	375	34
2005	1613	1297	316	459	439	20	1154	858	296	28
2006	1059	828	231	221	214	7	838	614	224	21
2007	819	635	184	171	156	15	648	479	169	21
2008	1018	770	248	188	177	11	830	593	237	18
2009	1595	1253	342	451	400	51	1144	853	291	28
2010	2133	1725	408	872	826	46	1261	899	362	41
2011	1908	1503	405	645	586	59	1263	917	346	34
2012	1913	1556	357	900	813	87	1013	743	270	47

Table 5. Catch by species for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2012.

Year	*YFT*	*SKJ*	*BET*	*ALB*	*OTH*	*TOTAL*
1991	30172	31814	3327	50	554	65917
1992	30778	20383	4985	451	930	57526
1993	33590	31537	10629	565	500	76821
1994	32381	30251	10075	130	1118	73955
1995	27850	22542	6262	83	1099	57836
1996	32179	21370	6778	191	725	61243
1997	29065	13335	4209	39	503	47150
1998	30468	14144	3641	40	927	49221
1999	28833	19457	3383	13	507	52194
2000	29506	16642	3936	23	434	50540
2001	31183	13774	3943	11	275	49186
2002	32982	13806	3597	18	211	50614
2003	32268	17318	3289	63	616	53554
2004	23413	19982	2417	19	264	46094
2005	22073	12606	1913	478	47	37117
2006	18353	5423	2402	347	12	26536
2007	12775	4012	1485	12	98	18382
2008	15929	3661	989	50	37	20666
2009	18545	6602	2043	60	24	27274
2010	19974	13983	3199	109	99	37365
2011	21427	12088	3268	53	152	36990
2012	18243	11749	3574	161	351	34077

Table 6. Catch by species made on FAD-associated schools for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2012.

Year	*YFT*	*SKJ*	*BET*	*ALB*	*OTH*	*TOTAL*
1991	4476	16465	2501	0	136	23578
1992	6116	16370	3619	0	509	26614
1993	6723	23884	6853	0	432	37892
1994	9124	22273	8372	0	721	40489
1995	5549	18155	5274	4	933	29915
1996	5750	16736	4941	0	559	27985
1997	4371	9076	2945	0	457	16850
1998	4669	8725	2712	0	787	16893
1999	5795	11478	2316	0	289	19877
2000	4335	11207	2696	0	405	18643
2001	3090	8792	2335	0	243	14459
2002	4198	9308	2287	0	164	15957
2003	4332	10937	1833	0	372	17473
2004	3742	14602	1901	0	191	20435
2005	2547	9805	1165	5	47	13569
2006	626	3925	541	0	12	5104
2007	850	3112	489	0	98	4549
2008	557	2103	391	0	37	3088
2009	1089	5531	939	0	24	7583
2010	3001	11297	1530	13	92	15932
2011	1978	9443	1776	12	96	13305
2012	2756	11335	2321	15	312	16739

Table 7. Catch by species made on free-swimming schools for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2012.

Year	*YFT*	*SKJ*	*BET*	*ALB*	*OTH*	*TOTAL*
1991	25696	15349	826	50	417	42339
1992	24662	4013	1366	451	421	30913
1993	26867	7653	3776	565	68	38929
1994	23257	7979	1703	130	397	33466
1995	22301	4387	988	79	166	27921
1996	26430	4634	1837	191	167	33258
1997	24694	4259	1264	39	46	30301
1998	25799	5419	930	40	140	32328
1999	23038	7980	1067	13	218	32316
2000	25170	5435	1240	23	30	31897
2001	28094	4982	1608	11	33	34727
2002	28784	4498	1310	18	46	34657
2003	27936	6382	1456	63	244	36081
2004	19671	5380	516	19	73	25660
2005	19527	2801	749	472	0	23548
2006	17727	1498	1861	347	0	21433
2007	11925	900	996	12	0	13834
2008	15372	1558	598	50	0	17578
2009	17456	1071	1104	60	0	19691
2010	16973	2687	1668	97	8	21433
2011	19449	2646	1493	41	56	23685
2012	15486	414	1253	146	39	17339

Table 8. Number of sets per searching on FAD-associated (FAD) and free-swimming schools (FSC) for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2012.

Year	*ALL*	*FAD*	*FSC*
1991	0.77	0.2	0.57
1992	0.66	0.23	0.43
1993	0.81	0.3	0.52
1994	0.74	0.33	0.42
1995	0.84	0.38	0.47
1996	0.9	0.34	0.56
1997	0.68	0.21	0.47
1998	0.75	0.26	0.5
1999	0.8	0.21	0.59
2000	0.77	0.2	0.57
2001	0.7	0.18	0.52
2002	0.75	0.2	0.55
2003	1	0.25	0.75
2004	0.84	0.29	0.55
2005	0.82	0.23	0.59
2006	0.89	0.19	0.7
2007	0.73	0.15	0.58
2008	0.97	0.18	0.79
2009	0.94	0.27	0.68
2010	1.01	0.41	0.6
2011	1.05	0.35	0.69
2012	0.92	0.43	0.49

Table 9. Catch per unit of effort (in t per positive set) on FAD-associated schools for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2012.

Year	*YFT*	*SKJ*	*BET*	*ALB*	*OTH*	*TOTAL*
1991	5.8	21.33	3.24	0	0.18	30.54
1992	7.14	19.1	4.22	0	0.59	31.05
1993	6.02	21.4	6.14	0	0.39	33.95
1994	7.04	17.19	6.46	0	0.56	31.24
1995	4.29	14.03	4.08	0	0.72	23.12
1996	4.74	13.81	4.08	0	0.46	23.09
1997	6.03	12.52	4.06	0	0.63	23.24
1998	5.11	9.56	2.97	0	0.86	18.5
1999	8.87	17.58	3.55	0	0.44	30.44
2000	6.97	18.02	4.33	0	0.65	29.97
2001	5.52	15.7	4.17	0	0.43	25.82
2002	7.7	17.08	4.2	0	0.3	29.28
2003	6.54	16.52	2.77	0	0.56	26.39
2004	5.59	21.83	2.84	0	0.29	30.55
2005	5.8	22.33	2.65	0.01	0.11	30.91
2006	2.93	18.34	2.53	0	0.06	23.85
2007	5.45	19.95	3.13	0	0.63	29.16
2008	3.15	11.88	2.21	0	0.21	17.45
2009	2.72	13.83	2.35	0	0.06	18.96
2010	3.63	13.68	1.85	0.02	0.11	19.29
2011	3.38	16.11	3.03	0.02	0.16	22.7
2012	3.39	13.94	2.85	0.02	0.38	20.59

Table 10. Catch per unit of effort (in t per positive set) on free-swimming schools for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2012.

Year	*YFT*	*SKJ*	*BET*	*ALB*	*OTH*	*TOTAL*
1991	14.69	8.78	0.47	0.03	0.24	24.21
1992	19.22	3.13	1.06	0.35	0.33	24.09
1993	17.51	4.99	2.46	0.37	0.04	25.38
1994	18.1	6.21	1.33	0.1	0.31	26.04
1995	18.37	3.61	0.81	0.07	0.14	23
1996	18.13	3.18	1.26	0.13	0.11	22.81
1997	20.87	3.6	1.07	0.03	0.04	25.61
1998	20.66	4.34	0.74	0.03	0.11	25.88
1999	17.17	5.95	0.8	0.01	0.16	24.08
2000	18.66	4.03	0.92	0.02	0.02	23.65
2001	20.9	3.71	1.2	0.01	0.02	25.84
2002	25.41	3.97	1.16	0.02	0.04	30.59
2003	17.45	3.99	0.91	0.04	0.15	22.54
2004	19.91	5.45	0.52	0.02	0.07	25.97
2005	22.76	3.26	0.87	0.55	0	27.45
2006	28.87	2.44	3.03	0.57	0	34.91
2007	24.9	1.88	2.08	0.03	0	28.88
2008	25.92	2.63	1.01	0.08	0	29.64
2009	20.46	1.26	1.29	0.07	0	23.08
2010	18.88	2.99	1.86	0.11	0.01	23.84
2011	21.21	2.89	1.63	0.04	0.06	25.83
2012	20.84	0.56	1.69	0.2	0.05	23.34

Table 11. Catch per unit of effort (in t per searching day) on FAD-associated schools for the French purse seine fishery of the Atlantic Ocean during 1991-2012.

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1991	1.07	3.93	0.6	0	0.03	5.62
1992	1.5	4.02	0.89	0	0.13	6.54
1993	1.69	6.02	1.73	0	0.11	9.55
1994	2.16	5.27	1.98	0	0.17	9.58
1995	1.49	4.88	1.42	0	0.25	8.05
1996	1.47	4.28	1.26	0	0.14	7.16
1997	1.14	2.37	0.77	0	0.12	4.4
1998	1.22	2.27	0.71	0	0.21	4.4
1999	1.69	3.34	0.67	0	0.08	5.79
2000	1.27	3.28	0.79	0	0.12	5.45
2001	0.86	2.45	0.65	0	0.07	4.03
2002	1.42	3.15	0.77	0	0.06	5.4
2003	1.53	3.86	0.65	0	0.13	6.16
2004	1.52	5.91	0.77	0	0.08	8.28
2005	1.29	4.97	0.59	0	0.02	6.88
2006	0.53	3.3	0.45	0	0.01	4.29
2007	0.75	2.76	0.43	0	0.09	4.04
2008	0.53	2	0.37	0	0.04	2.94
2009	0.64	3.27	0.55	0	0.01	4.48
2010	1.42	5.35	0.73	0.01	0.04	7.55
2011	1.09	5.19	0.98	0.01	0.05	7.31
2012	1.33	5.45	1.12	0.01	0.15	8.05

Table 12. Catch per unit of effort (in t per searching day) on free swimming schools for the French purse seine fishery of the Atlantic Ocean during 1991-2012.

Year	*YFT*	*SKJ*	*BET*	*ALB*	*OTH*	*TOTAL*
1991	6.13	3.66	0.2	0.01	0.1	10.1
1992	6.06	0.99	0.34	0.11	0.1	7.6
1993	6.77	1.93	0.95	0.14	0.02	9.81
1994	5.5	1.89	0.4	0.03	0.09	7.92
1995	6	1.18	0.27	0.02	0.04	7.51
1996	6.76	1.19	0.47	0.05	0.04	8.51
1997	6.45	1.11	0.33	0.01	0.01	7.91
1998	6.72	1.41	0.24	0.01	0.04	8.42
1999	6.71	2.32	0.31	0	0.06	9.41
2000	7.36	1.59	0.36	0.01	0.01	9.33
2001	7.82	1.39	0.45	0	0.01	9.67
2002	9.74	1.52	0.44	0.01	0.02	11.73
2003	9.85	2.25	0.51	0.02	0.09	12.72
2004	7.97	2.18	0.21	0.01	0.03	10.39
2005	9.9	1.42	0.38	0.24	0	11.94
2006	14.91	1.26	1.57	0.29	0	18.02
2007	10.59	0.8	0.88	0.01	0	12.28
2008	14.62	1.48	0.57	0.05	0	16.72
2009	10.31	0.63	0.65	0.04	0	11.63
2010	8.04	1.27	0.79	0.05	0	10.16
2011	10.68	1.45	0.82	0.02	0.03	13.01
2012	7.45	0.2	0.6	0.07	0.02	8.34

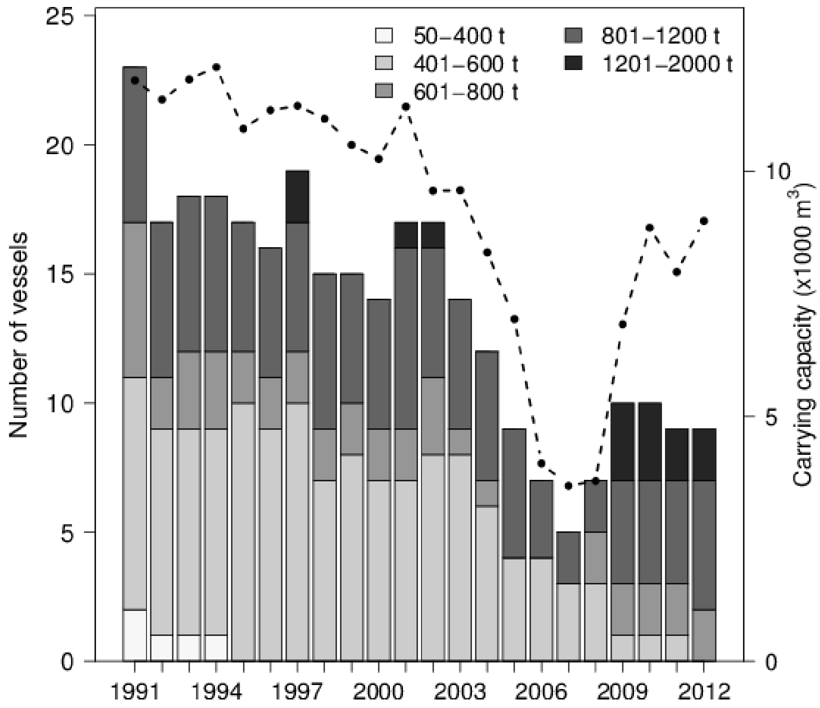

Figure 1. Fishing capacity of the French purse seine fishing fleet in the Atlantic Ocean. Annual changes in the number of purse seiners by size category (barplots) and total carrying capacity (solid line with circles) during 1991-2012. Capacity was weighted by the vessel-specific proportion of the year at sea (in months). The vessel size category (t) was computed as 0.7 times the capacity expressed in m^3.

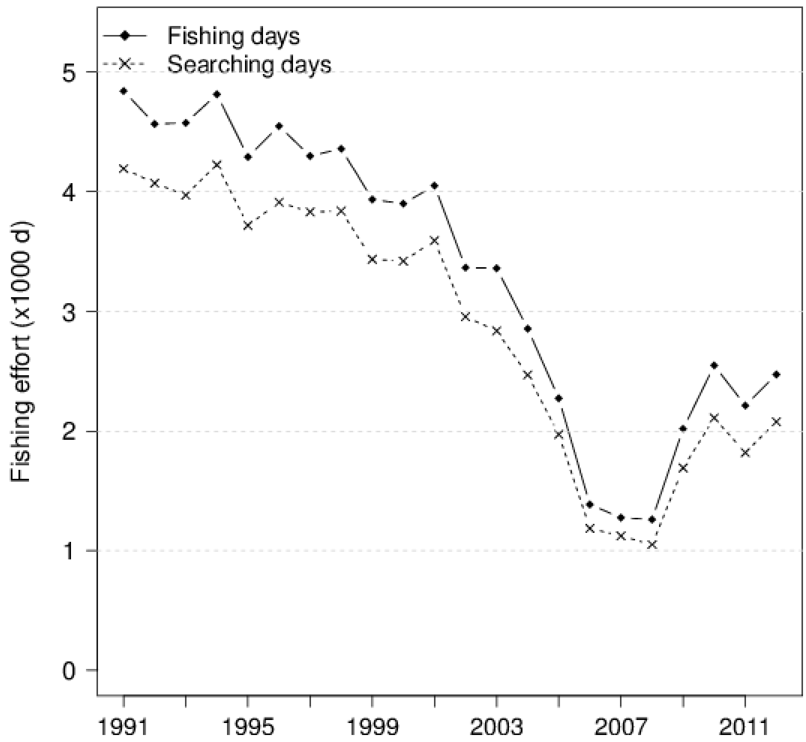

Figure 2. Changes in nominal effort over time. Annual total number of fishing and searching days for the French purse seine fishing fleet in the Atlantic Ocean during 1991-2012.

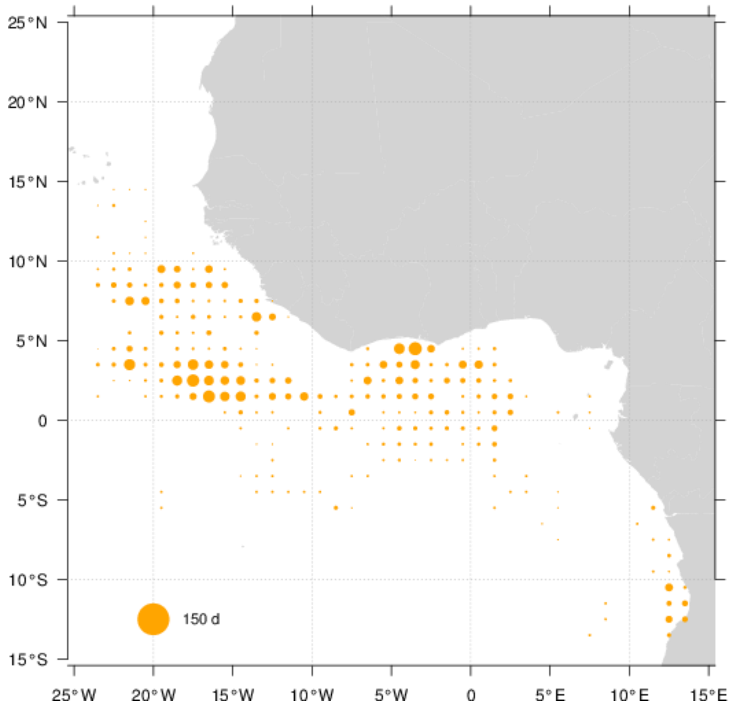

Figure 3. Fishing grounds. Spatial distribution of fishing effort (in searching days) of the French purse seine fishing fleet in 2012.

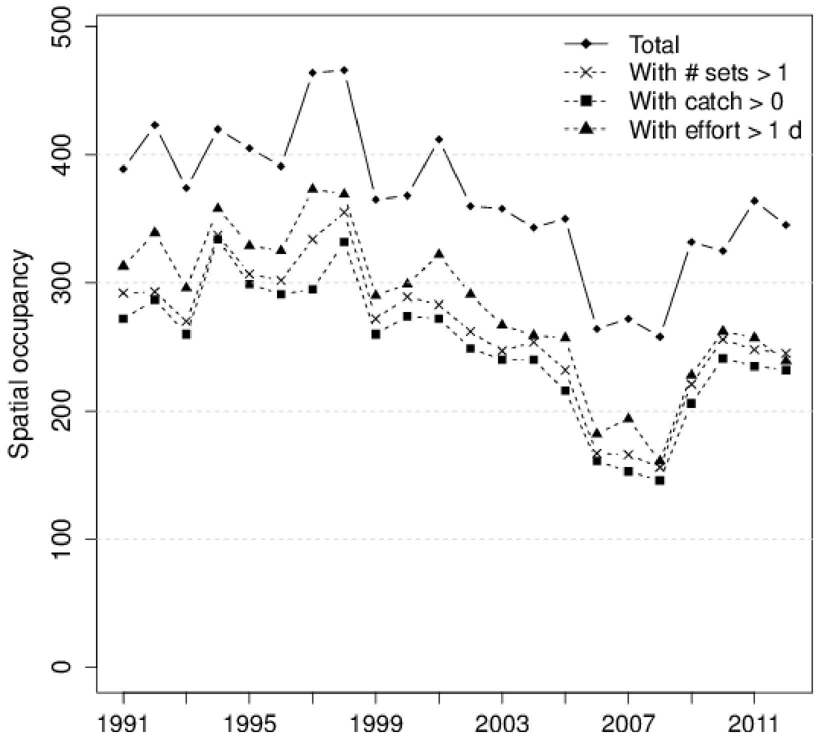

Figure 4. Changes in spatial extent of the fishery over time. Mean annual number of 1-degree squares explored by each vessel of the French purse seine fishing fleet during 1991-2012. Solid line indicates standard deviation. Only vessels in activity during 12 months were selected. A loess function was fitted to the data to illustrate the trend.

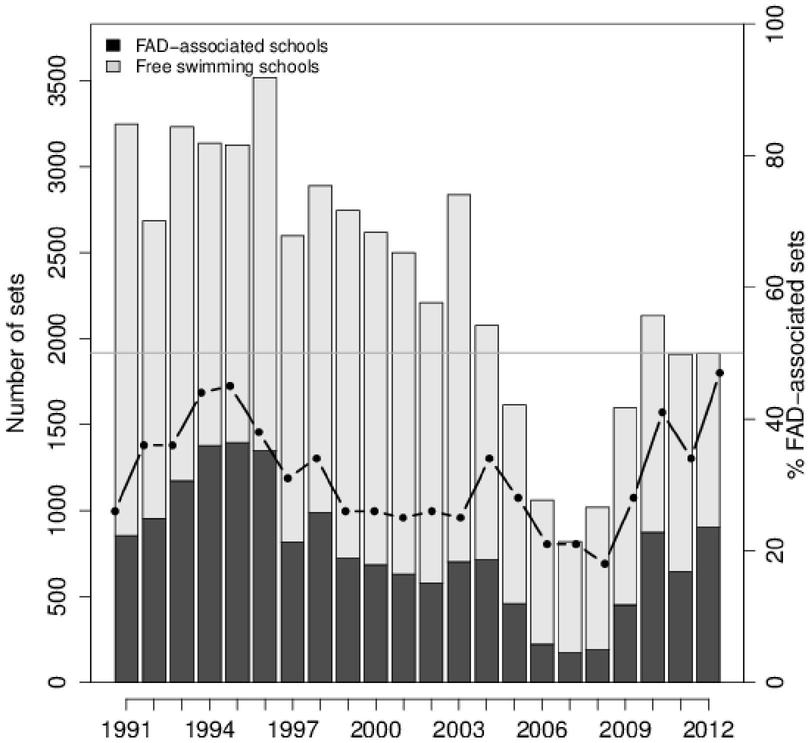

Figure 5. Fishing operations. Annual number of fishing sets in the French purse seine fishery on FAD-associated and free-swimming schools during 1991-**2012**. Line with solid circles indicates the percentage of sets made on FAD-associated schools over free-swimming schools. Grey solid line indicates the 50% value.

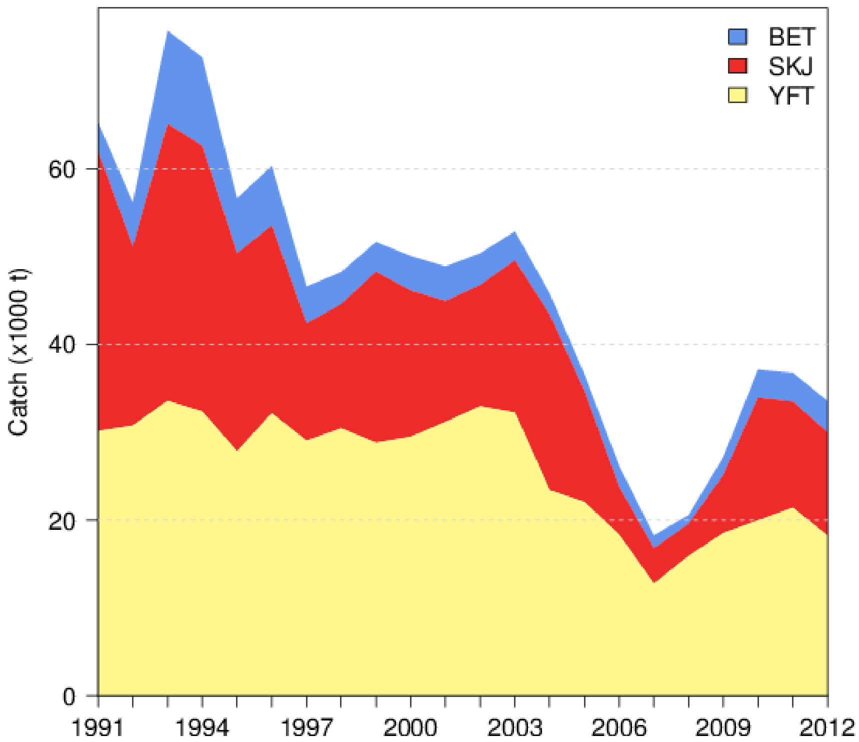

Figure 6. Total fishery production. Catch by species of the French purse seine fishing fleet during 1991-2012.

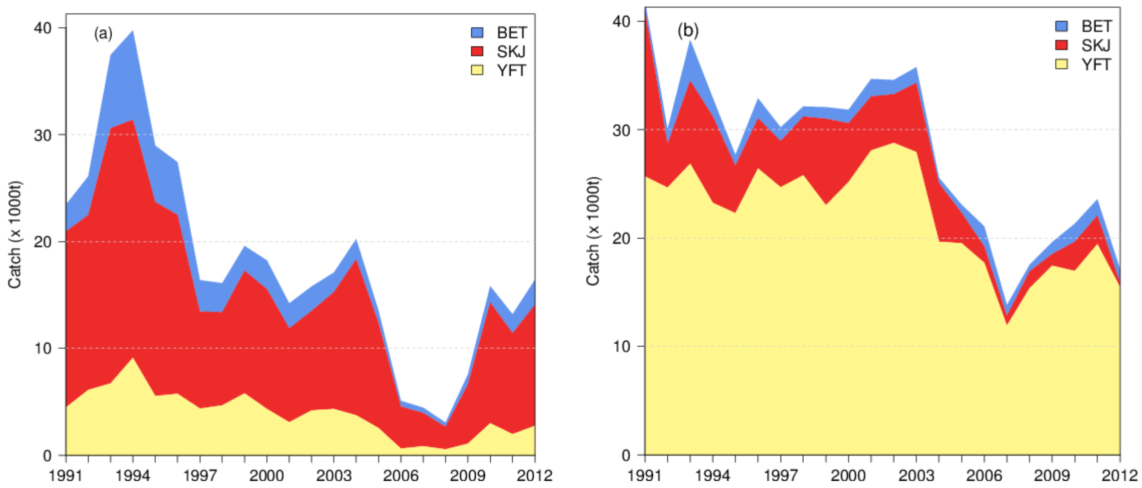

Figure 7. Fishery production by major fishing mode. Catch by species of the French purse seine fishing fleet on (a) FAD-associated and (b) free-swimming schools during 1991-2012.

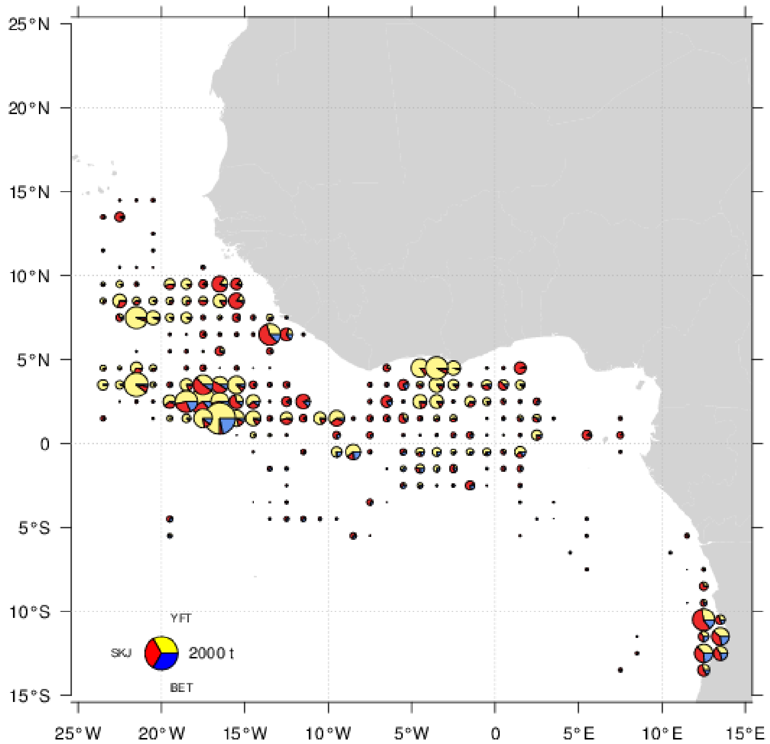

Figure 8. Spatial distribution of tuna catches of the French purse seine fishing fleet in 2012.

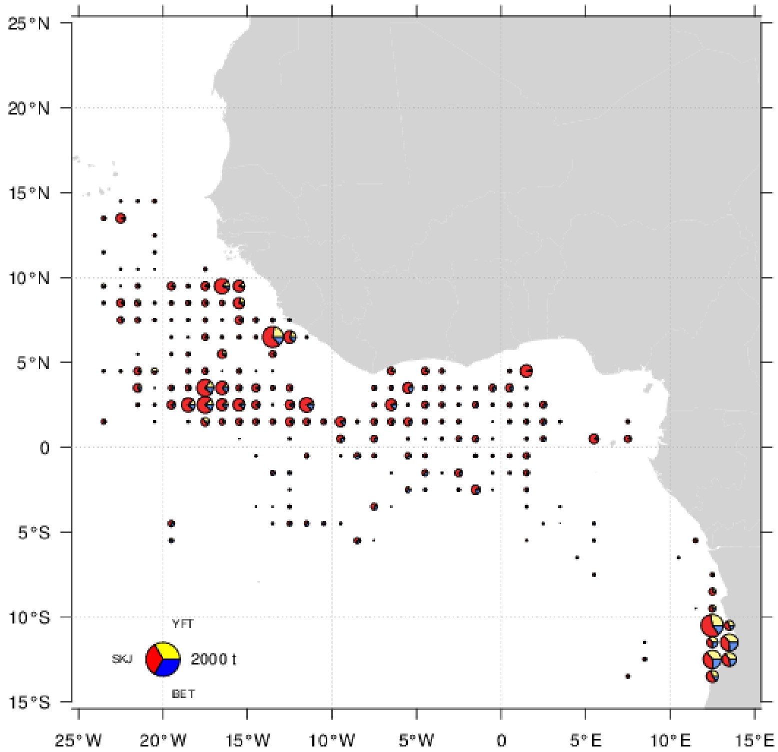

Figure 9. Spatial distribution of tuna catches of the French purse seine fishing fleet made on FAD-associated schools in 2012.

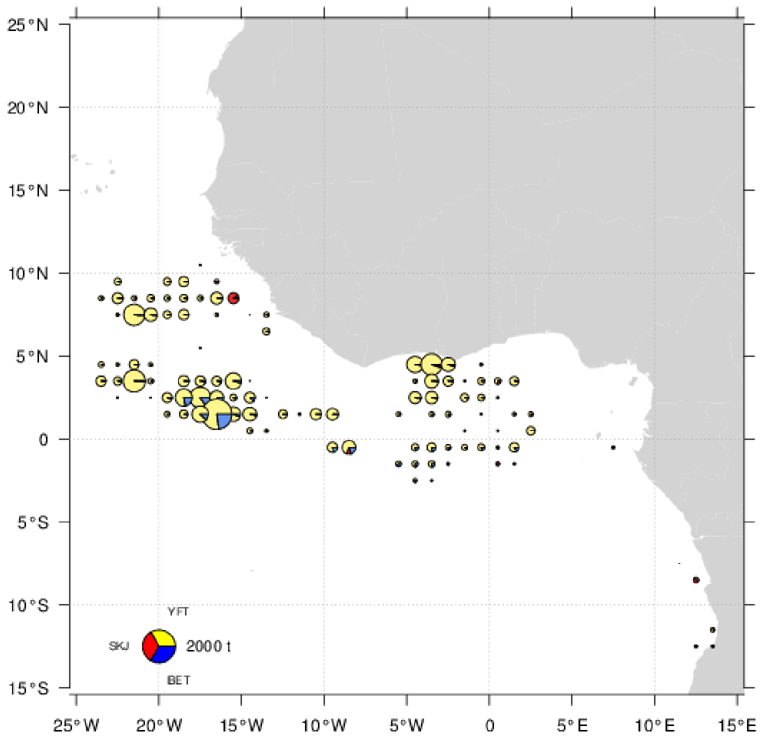

Figure 10. Spatial distribution of tuna catches of the French purse seine fishing fleet made on FSC-associated schools in 2012.

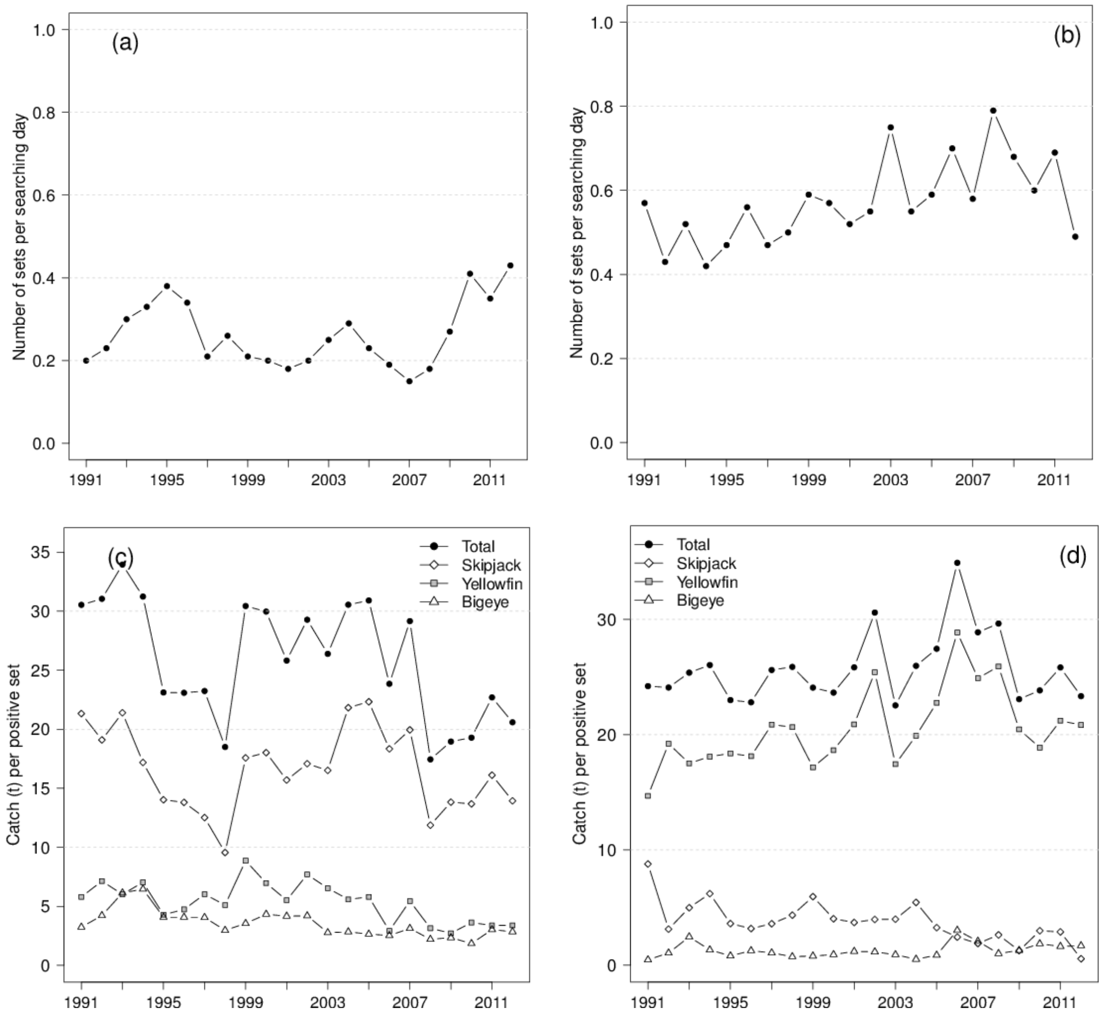

Figure 11. (a-b) Annual number of sets per searching day and (c-d) catch per positive set on (left panel) FAD-associated and (right panel) free-swimming schools for the French purse seine fishing fleet in the Atlantic Ocean during 1991-2012 .

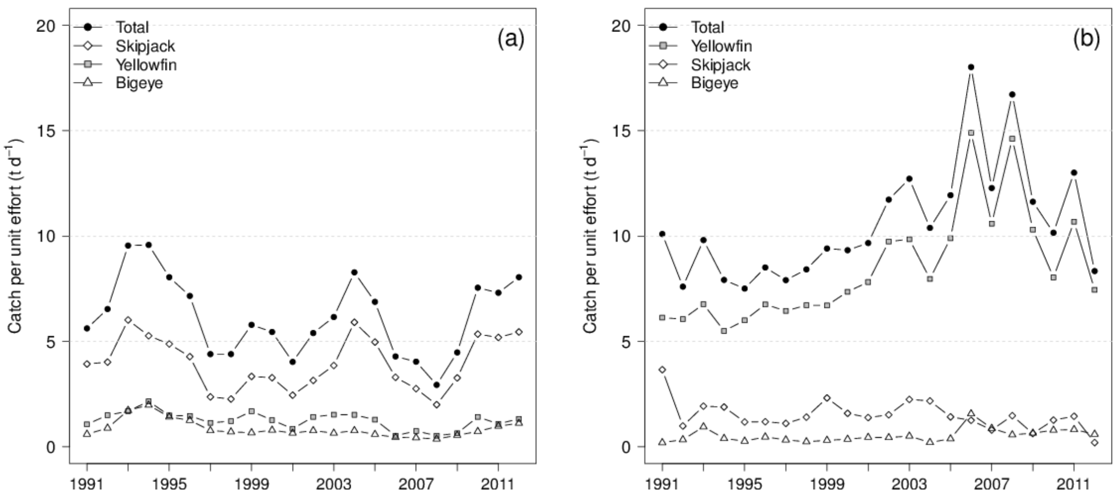

Figure 12. Annual catch rates (in t per searching day) of the French purse seine fishing fleet on (a) FAD-associated and (b) free-swimming schools in the Atlantic Ocean during 1991-2012.

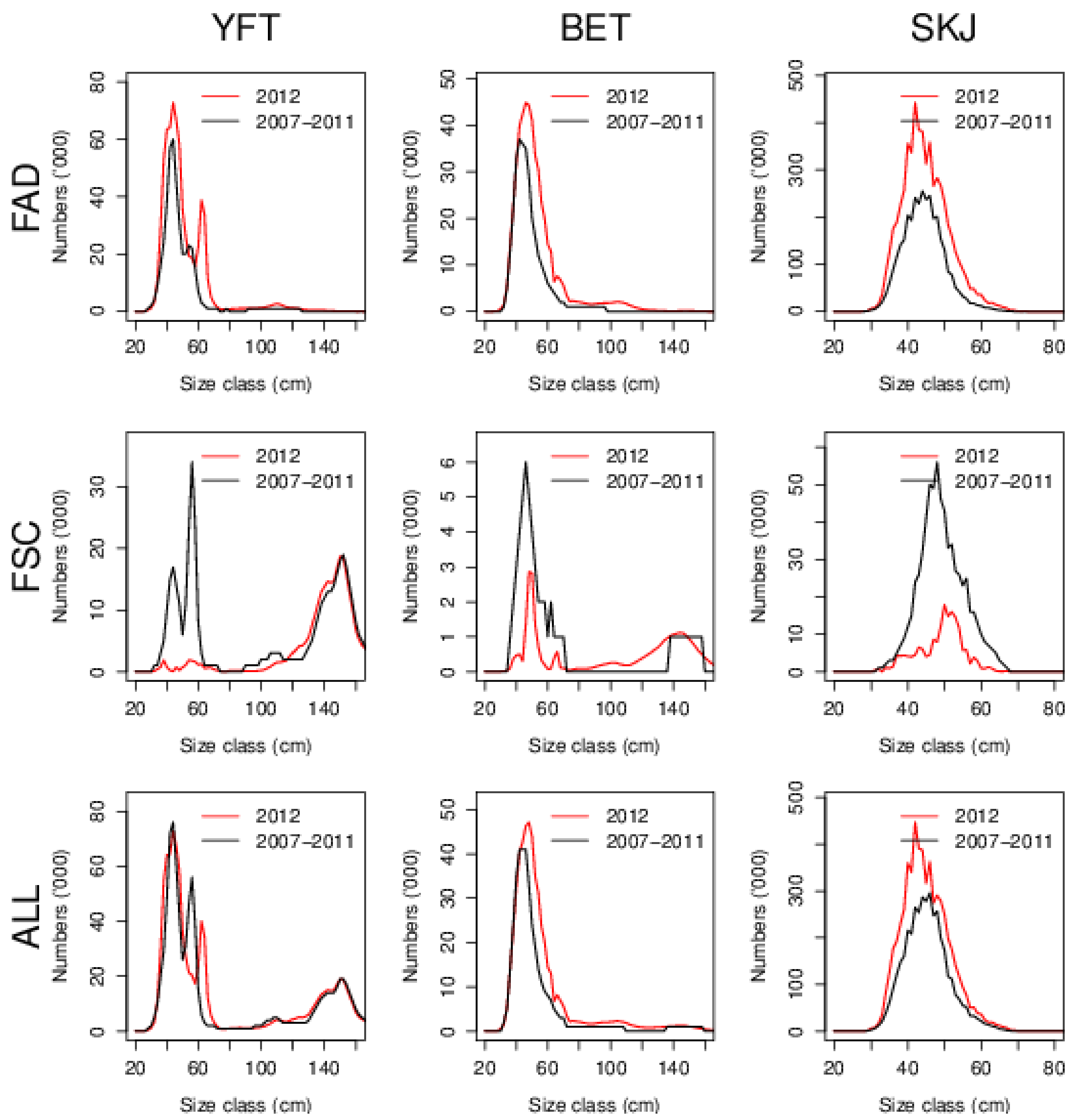

Figure 13. Size distribution of the catch (in numbers) for the French purse seine fleet in 2012 (red line) and for an average year representing the period 2007-2011 (black line).

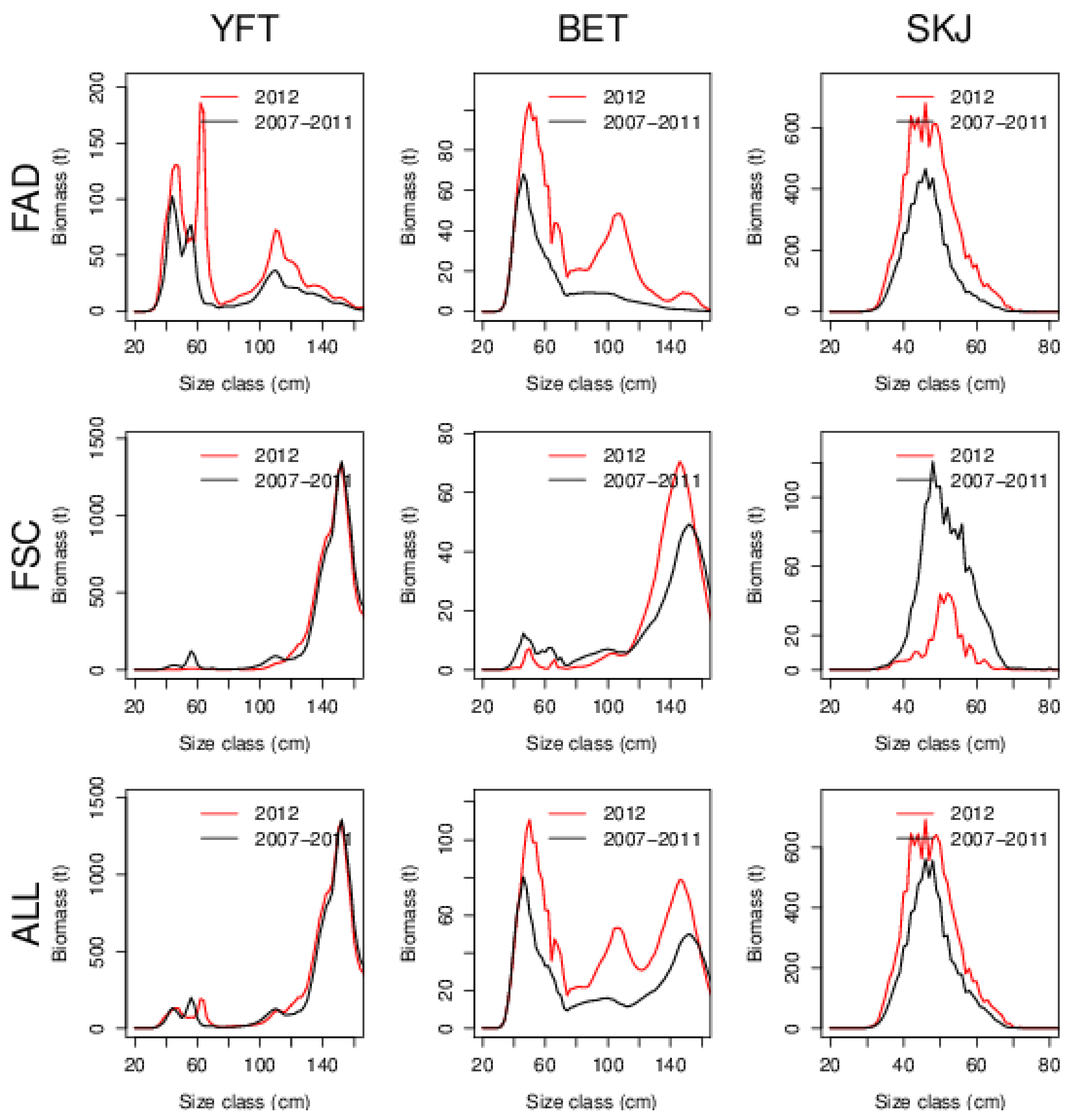

Figure 14. Size distribution (in weight) of the catch for the French purse seine fleet in 2012 (red line) and for an average year representing the period 2007-2011 (black line).

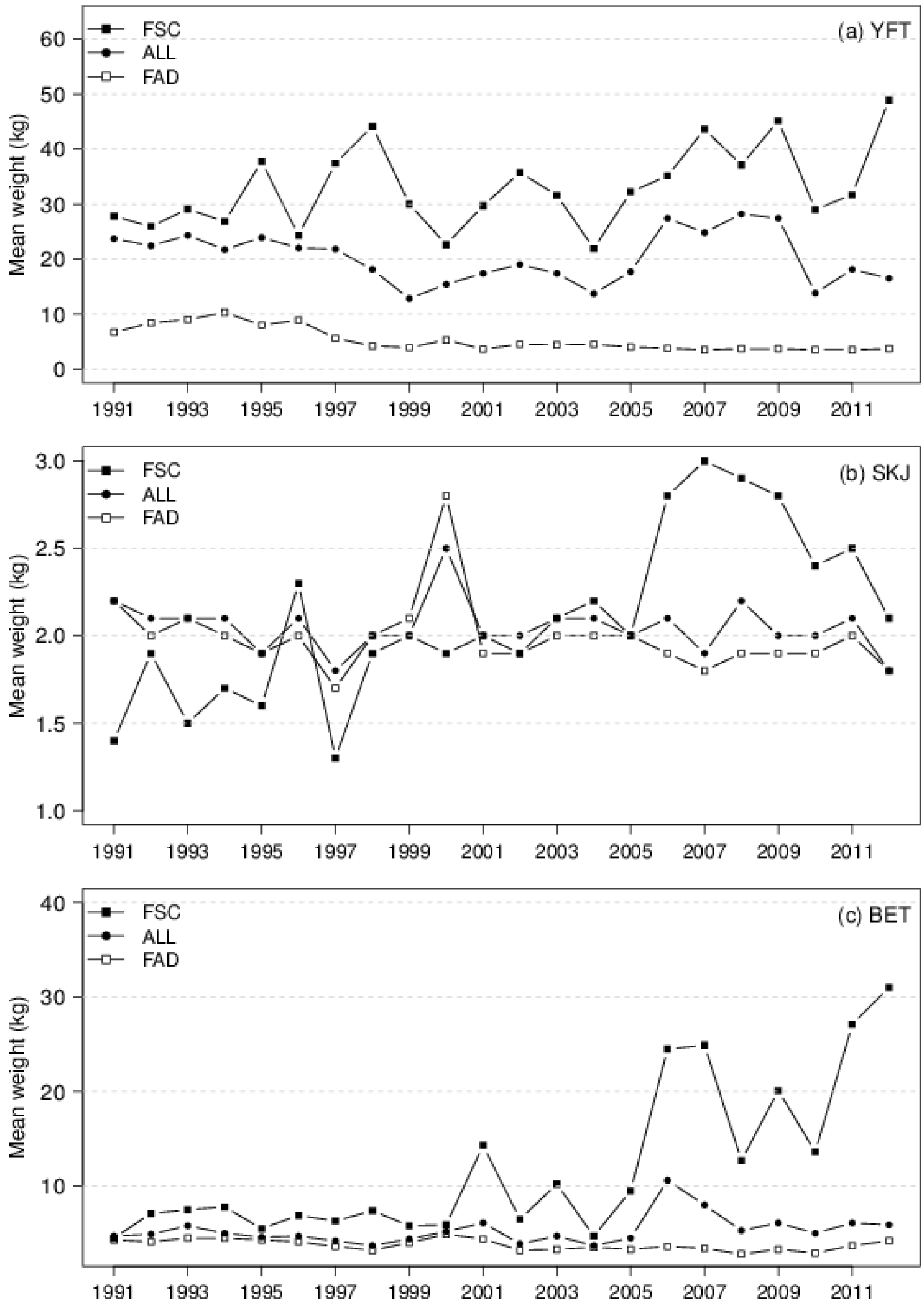

Figure 15. Annual time series of mean weight (kg) for (a) yellowfin, (b) skipjack, and (c) bigeye tuna for each fishing mode during 1991-2012.

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ANAYSIS OF GHANAIAN INDUSTRIAL TUNA FISHERIES DATA: TOWARDS TASKS I AND II FOR 2006-2012

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SUMMARY

Ghanaian industrial tuna fisheries collected during 2006-2012 were analysed to define the main features of the available datasets and propose a framework for estimating the ICCAT tasks I and II. Data coverage and quality have greatly improved over the recent years as reflected by the increasing amount of logbooks collected, the decrease in the proportion of unknown type schools in the baitboat (BB) and purse seiner (PS) logbooks, the consistency between landings and logbook catches that were found to be very close to the total task I declared in 2012. For the first time in 2012, all logbooks for the PANOFI fleet became available and enabled to improve our understanding of the spatio-temporal patterns of this major component of the Ghanaian PS fleet, which represented about 50% of the total PS catch during 2006-2012. Regarding the difference in fishing grounds between the PANOFI purse seiners and the rest of the fleet, we propose to consider 3 distinct fleets for data processing: (i) baitboats, (ii) the PS PANOFI fleet (P-Fleet), and the other purse seiners (A-Fleet). Based on all data available, we first propose to increase the total task I of Ghanaian BB and PS for some years. Second, we make some assumptions to distribute the total catch between fleets and in time (months) and space (5°-squares of latitude and longitude). Third, we justify the use of size-samples collected from European purse seiner sets made on fish-aggregating devices (FADs) to estimate the size and species composition of Ghanaian BB and PS. We used a sampling scheme based on years and three spatial areas to estimate the species composition of the Ghanaian BB and PS. This sampling however results in some small numbers of samples for some strata which could bias the species composition. Based on the results of the processing, we propose a new Task I for Ghanaian tuna fisheries for 2006-2012. Perspectives of the work are presented, including some extensions of the tool T3+ currently in development which is devoted to the processing of BB and PS data and could strongly facilitate future analyses of Ghanaian fisheries data.

RÉSUMÉ

Les données des pêcheries industrielles de thonidés ghanéennes recueillies entre 2006 et 2012 ont été analysées afin de définir les principales caractéristiques des jeux de données disponibles et proposer un cadre d'estimation des données de Tâche I et II de l'ICCAT. La couverture et la qualité des données se sont nettement améliorées au cours de ces dernières années grâce au volume croissant des carnets de pêche recueillis, à la diminution de la proportion des types de bancs inconnus dans les carnets de pêche des canneurs (BB) et des senneurs (PS), à la cohérence entre les débarquements et les prises consignées dans les livres de bord qui se sont avérées très proches du total de la Tâche I déclaré en 2012. Pour la première fois en 2012, tous les carnets de pêche pour la flottille PANOFI ont été disponibles et ont permis d'améliorer notre compréhension des schémas spatio-temporels de cet élément important de la flottille de senneurs ghanéens, qui représentait environ 50% de la prise totale des senneurs entre 2006 et 2012. En ce qui concerne la différence de zones de pêche entre les senneurs de la flottille PANOFI et le reste de la flottille, nous proposons d'envisager trois flottilles distinctes aux fins du traitement des données : (i) canneurs, (ii) flottille de senneurs PANOFI (P-Fleet) et les autres senneurs (A-Fleet). Sur la base de toutes les données disponibles, nous proposons d'abord d'augmenter le total de la Tâche I des canneurs et senneurs ghanéens pour certaines années. Deuxièmement, nous formulons des postulats afin de distribuer la prise totale entre les flottilles et dans le temps (mois) et l'espace (carrés de 5° de

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latitude et longitude). Troisièmement, nous justifions l'emploi d'échantillons de taille prélevés pendant les opérations des senneurs européens réalisées sur des dispositifs de concentration du poisson (DCP) afin d'estimer la composition par espèce et par taille des prises des canneurs et des senneurs ghanéens. Nous avons utilisé un programme d'échantillonnage basé sur les années et trois zones spatiales afin d'estimer la composition des espèces des prises des canneurs et des senneurs ghanéens. Cet échantillonnage a toutefois été réalisé avec un nombre réduit d'échantillons pour certaines strates, ce qui pourrait fausser la composition des espèces. En fonction des résultats obtenus du traitement, nous proposons une nouvelle Tâche I pour les pêcheries de thonidés ghanéennes pour 2006-2012. Les perspectives des travaux sont présentées, y compris quelques extensions de l'outil T3+ en cours d'élaboration qui est dédié au traitement des données des canneurs et des senneurs et pourrait fortement faciliter les futures analyses des données des pêcheries ghanéennes.

RESUMEN

Se analizaron los datos de la pesquería industrial de túnidos de Ghana recopilados desde 2006 hasta 2012 para definir los rasgos principales de los conjuntos de datos disponibles y proponer un marco para estimar la Tarea I y la Tarea II de ICCAT. La cobertura y calidad de los datos ha mejorado en gran medida en años recientes, tal y como se evidencia en el mayor número de cuadernos de pesca recopilados, el descenso de la proporción de tipo de bancos desconocidos en los cuadernos de pesca de los cañeros (BB) y cerqueros (PS), la coherencia entre los desembarques y las capturas de los cuadernos de pesca, que recogen cantidades muy similares al total de Tarea I declarado en 2012. Por primera vez en 2012, todos los cuadernos de pesca para la flota PANOFI estuvieron disponibles y permitieron mejorar nuestra comprensión del patrón espacio-temporal de este importante componente de la flota de cerco de Ghana, que respondió de aproximadamente el 50% de la captura de cerco total durante 2006-2012. En cuanto a la diferencia en los caladeros entre los cerqueros de PANOFI y el resto de la flota, proponemos que se consideren tres flotas diferentes a efectos de procesamiento de los datos: (i) cerqueros, (ii) flota de cerqueros de PANOFI (flota P), y otros cerqueros (flota A). Basándose en los datos disponibles, proponemos en primer lugar un incremento del total de Tarea I de BB y PS de Ghana para algunos años. En segundo lugar, empleamos algunos supuestos para distribuir la captura total entre las flotas y en el tiempo (meses) y en el espacio (cuadrículas de 5º de latitud y longitud). En tercer lugar, justificamos la utilización de muestras de talla recogidas en lances de los cerqueros europeos realizados sobre dispositivos de concentración de peces (DCP) para estimar la composición por tallas y especies de BB y PS de Ghana. Utilizamos un programa de muestreo basado en los años y tres zonas espaciales para estimar la composición por especies de BB y PS de Ghana. Sin embargo, este muestreo tiene como resultado algunos números pequeños de muestras para algunos estratos lo que podría sesgar la composición por especies. Basándose en los resultados del procesamiento, proponemos una nueva Tarea I para las pesquerías de túnidos de Ghana para el periodo 206-2012. Se incluyen algunas perspectivas de trabajo como la ampliación de la herramienta T3+, que se está desarrollando actualmente y que sirve para procesar los datos BB y PS y podría facilitar en gran medida los análisis futuros de los datos de las pesquerías de Ghana.

KEYWORDS

Baitboat, Purse seining, FAD, bigeye, skipjack, yellowfin

1 Introduction

The monitoring of the Ghanaian industrial tuna fisheries has improved in the recent years through better data collection of purse seine (PS) and baitboat (BB) data. Fonteneau et al. (2013) made a comprehensive analysis of the Ghanaian fisheries data collected during 1996-2005 and identified gaps and caveats in the data to draw directions for the processing of data available for 2006-2012. Following a workshop conducted between MFRD and IRD in May 2013, a full AVDTH (v3.3) database compiling all available information on fisheries logbooks, landings (i.e. sale records), and size samples covering the period 2006-2012 was built. Damiano et al. (2013) showed that the sampling of tuna landings conducted in Ghana until July 2012 resulted in some bias in size-frequency histograms. Sampling operations have been modified since then to comply with the standard protocol used for the European purse seine and baitboat fisheries (Damiano et al. 2013). The present document aims to describe the steps and assumptions used to process the Ghanaian fisheries data and estimate the Tasks I and II for the period 2006-2012. First, a general description of the data is made to assess the overall data quality and point out some of the assumptions required for data processing. The steps for processing the Ghanaian fisheries data are then presented so as provide a framework to estimate the ICCAT tasks I and II.

2 Data description

Following the workshop held in May 2013, corrections were made in the referential list of Ghanaian vessels (Chassot et al. 2013). The number of active BB was found to be consistent between landings and logbooks and decreased from 20 in 2006 to 14 in 2012 (**Table 1**). By contrast, information on the number of active PS differed between landings and logbooks and data availability improved over the years with logbooks and landings data becoming available in 2012 for 16 Ghanaian PS (**Table 1**). Little information was available in 2007 for both fishing gears. The annual number of days of activity per vessel recorded in the logbooks strongly varied between vessels for both fishing gears. The overall median value was 186 d y^{-1} and 174 d y^{-1} for BB and PS, respectively (**Figure 1**).

The information available in the Ghanaian vessel logbooks improved over 2006-2012 for both BB and PS. The cumulated catch declared in all vessel logbooks increased from a total of about 45,000 t in 2006 to almost 80,000 t in 2012 (**Figure 2**). In 2012, total catches and landings were at similar levels and close to the total Task I (**Table 4**). Meanwhile, the percentage of schools of indeterminate type decreased from 80% to 10% and from 25% to 5% for BB and PS, respectively (**Figure 3**). During 2010-2012, when the percentage of indeterminate schools was low (<13%), fish aggregating devices (FAD) sets represented 55% (SD = 8%) of all BB sets. By contrast, FAD-fishing largely predominated in the PS fishery, representing 85% of all sets during 2006-2012 (**Figure 3**). The success rates of PS sets on FADs and free-swimming schools (FSC) were found to be 98% and 85%, respectively. This would suggest that some null sets might not be recorded in the logbooks as the success rates on FAD and FSC sets for the European PS fishery are generally close to 95% and 70%, respectively (Delgado de Molina et al. 2013).

In 2012, logbook information became fully available for the PANOFI fleet (P-fleet) which was composed of 6 purse seiners: Frontier, Master, Volunteer, Discoverer, Pathfinder, and Forerunner. The cumulated catch of the P-fleet was more than 27,000 t in 2012, representing 50% of the catch of the Ghanaian PS fishery (**Table 2**). Little information from the logbooks was available for the P-fleet for the period 2006-2011.

Landing data indicated that the number of PANOFI vessels increased from 3 to 6 in 2010. The website of Silla (http://www.sla.co.kr/eng/E2_1_5.htm) indicates that the Discoverer and Forerunner entered in operation in September and November 2009, respectively. The P-fleet represented >50% of the total PS landings during 2010-2012 (**Table 3**). The total landings of the P-fleet recorded in 2008-2009 appeared small relative to the landings recorded during 2006-2007. Little information on the activity of the PANOFI vessels is however available for this fleet during 2006-2011 but landings at around 17,000 t y^{-1} are rather consistent with an annual catch of about 5,000-6,000 t for 3 purse seiners of length overall of 56-57 m.

The spatial distribution of the catch of the P-fleet derived from 2012 logbooks was found to differ with the rest of the PS fleet (A-fleet), extending more toward the western part of the eastern Atlantic Ocean in each quarter of the year (**Figures 4-5**).

3 Processing of the catch data

The processing of the fisheries catch is composed of 5 steps (**Figure 6**). First, the total catch for each fishing gear is estimated from the different data sources available, i.e. current ICCAT Task I, logbooks, and landings. The total catch is split between the PANOFI (P-Fleet) and other PS (A-Fleet) and the BB. Second, the total catch is distributed among months based on the monthly seasonality derived from logbook data on a yearly basis. Third, the monthly total catch is distributed in space according to information available in the logbooks and accounting for the difference in spatial distribution between the 3 fleets. Finally, size samples available from the European purse seine fleet are used to estimate the species and size composition of the catch during 2006-2012 based on a spatio-temporal stratification proposed by Fonteneau et al. (2013).

3.1 Total annual catch

The total catches derived from PS and BB logbook declarations and landings available in the Ghana database were found to exceed the current ICCAT Task I in some years (**Table 4**). Considering the maximum value of the 3 data sources available, **Table 4** gives a proposal of modification of the total Ghana Task I in 2006 and 2011-2012 for the BB and in 2006, 2008-2012 for the PS. The new total Task I would result in a substantial increase in the total catch for BB in 2011 (+51.9%) and in the PS for 2006 (+99.5%), 2008 (+91.6%) and 2009 (+36.5%). Note than landings are estimated for the year of unloading which differs a bit from the year of catch due to trips overlapping two years.

The total annual PS catch was then split between the P-Fleet and the A-Fleet. For 2009-2012, we assumed that the catches recorded in the logbooks of the A-Fleet were reliable (**Table 2**) and computed the total catch of the P-Fleet as the difference between the proposed total Task I and the catch of the A-Fleet (**Table 4**). For 2006 and 2008, the percentage of catch for each fleet was derived from their respective contribution to the total landings (**Table 3**). For 2007, the contribution of each fleet to the total PS catch was computed as the average percentage estimated from the landings in 2006 and 2008, i.e. when three PANOFI purse seiners were in activity. The final total catches of each PS fleet are given in **Table 5**.

3.2 Distribution of the total catch between months

The mean monthly seasonality appeared quite similar for both fishing gears with a peak in catch during September-October (**Figure 7**). The monthly seasonality in the catch of the P-Fleet and the A-fleet showed a relatively similar pattern over the year 2012[5], although the contribution of the first quarter to the catch appeared smaller for the P-Fleet than for the A-Fleet (**Figure 8**). The mean monthly seasonality in landings during 2008-2012 showed a similar pattern between the P-Fleet and A-Fleet (**Figure 9**). Consequently, we assumed that the P-Fleet and A-Fleet had a similar distribution of catch across months each year and used the monthly percentage of catch computed for the A-Fleet during 2006-2011 for the P-Fleet. The total catch was distributed between each month of each year based on the monthly percentage of catch derived from the logbooks (**Table 6**), except for 2007 as only about 11% of the catch was available in the logbooks for this year. The average monthly percentage of catch for 2006 and 2008-2012 was used for 2007.

3.3 Distribution of the total catch in space

The spatial distribution of the catch was computed on a quarterly basis for each fleet, i.e. the BB, the A-Fleet, and the P-Fleet. The percentage of catch of the BB and A-Fleet in each 5°-square of latitude and longitude was estimated for each quarter based on the logbooks for 2006 and 2008-2012. For 2007, the distribution was computed as the average of the years 2006 and 2008 for each fleet. For the P-Fleet, information on fishing grounds from the logbooks was almost exclusively available for 2012. Here, we assumed that the quarterly spatial distribution of the P-Fleet was stable over 2006-2012. This assumption was supported by the fact that the three PANOFI purse seiners already operating in 2006-2009 (i.e. Frontier, Master, and Volunteer) showed a quarterly distribution in 2012 very similar to the three other PANOFI vessels which arrived in 2010 in the fishery (Discoverer, Forerunner, Pathfinder) (**Figures. 4-5**).

[5] Unique year for which logbooks of the P-Fleet are considered to be fully available

3.4 Species composition of the catch

We assumed here that all catches of the three Ghanaian fleets during 2006-2012 can be described by a size and species composition characteristic of tuna schools associated with FADs. Indeed, FAD-sets largely predominated in the PS fleets over the period and represented 94% of the total sets in 2012 (**Figure 3a**). By contrast, information on school type available in the BB logbooks suggests that a significant part of sets might have been made on free-swimming schools, e.g. 35% of the sets of known type in 2012 (**Figure 3b**). However, the sharing of catch between BB and PS at-sea is known to be common practice in the Ghanaian fishery. Samples conducted at unloading of BB and PS in Abidjan during 2003-2004 showed there was no significant difference in the size-structure and species composition of the catch between gears (Fonteneau et al. 2013). Similarly, the size-structure of the landings showed similar distribution in 2006-2008 between BB and PS (Kell et al. 2011).

Consequently, the size-samples collected from the European purse seine fishery during 2006-2012 from fishing sets made on FAD-associated schools were selected for estimating the species composition of the Ghanaian catch. We relied on the spatial stratification proposed by Fonteneau et al. (2013) which consists of 3 areas: (i) the coastal areas along Ivory Coast (CIV) and Ghana (GHA), (ii) the Cape Lopez area, and (iii) the offshore area (**Figure 10**). Adopting this stratification however resulted in the availability of a small amount of samples in the coastal areas of CIV and GHA, i.e. <10 for some years.

An average species composition derived from the samples collected from the European PS catch on FADs was computed for each spatial stratum on a yearly basis as the quarterly stratification currently in use for the European PS resulted in very high variability in species composition across strata and several strata without any sample. The yearly species composition of the FAD catch was found to be rather stable in offshore areas with about 67% SKJ, 14% YFT, and 15% BET (**Figure 11**). The yearly species composition of the catch in the Cape Lopez area was also rather stable over time, with the same magnitude of SKJ (66%) but more YFT (21%) and less BET (6%), as compared to the offshore area. By contrast, the species composition in the coastal areas of Ivory Coast and Ghana showed a strong interannual variability which might be due to the small sample size (**Figure 11**).

The species composition derived from the samples was assigned to the catch of the BB and PS according to the year and area of origin of the catch (see section 3.3). Annual catches by species and fleet are given in **Figures 12-14**.

4 Perspectives

4.1 Data processing

The processing of the catch data to estimate the Task I must be considered as preliminary as several points need to be elucidated. First, the proposal of total task I derived from the available data sources should be agreed by the SCRS. Second, the assumptions used to reallocate the catch across space and time (i.e. months) should be discussed and alternative scenarios might be considered. Third, the current spatio-temporal stratification suggested by Fonteneau et al. (2013) results in a lack of representativeness of the samples in some strata and calls for further analysis to define a better sampling scheme. These 3 major points should be analysed so as to agree upon a final method to estimate the spatio-temporal composition of the catch and eventually derive the Ghanaian tasks I and II over 2006-2012. Finally, a complementary analysis has to be conducted to estimate the nominal fishing effort for both purse seiners and baitboats over the period of interest.

4.2 Towards an integrated tool for processing Ghanaian fisheries data: T3+

Monitoring the Ghanaian BB and PP fisheries requires good data collection in the first place. The AVDTH software currently in use by MFRD and also employed for the European tropical tuna fisheries of the Atlantic and Indian Ocean provides a robust tool that combines a data entry application coupled with a MS ACCESS database. Several tools associated with AVDTH (Akado, Anapo, Babys, Acarto) enable to control the data quality and visualise the raw data collected. Data processing represents the second step to estimate the ICCAT tasks I and II from logbooks, landing, and sampling data. The software T3+ has been recently developed as a server application dedicated to the processing of BB and PS fisheries data (Cauquil 2012). T3+ enables (i) data importation from AVDTH databases, (ii) data processing through SQL/JAVA codes (e.g. length-weight conversions, raising) through successive steps, and (iii) production of data outputs for ICCAT. T3+ could be deployed on an ICCAT server so as (i) to avoid the installation of the tool on a specific machine and thus maintain a unique centralised database with controlled access, (ii) to host and mutualise size-samples collected from different fisheries of the Atlantic for data processing, and (iii) to ensure that historical assumptions and methods used to process the data are transparent and repeatable as they are stored in the database through specific configurations.

All intermediate results are stored in tables and can be currently accessed through SQL, R, PHP, etc. T3+ is still in development and future work could include the development of (i) a tool dedicated to the selection of the samples through a list of spatial layers and the possibility to construct its own spatial strata (e.g. Mapserver and Openlayers), (ii) libraries of SQL queries described and directly included in the database in the form of views, and (iii) an interface to easily extract the data processed (e.g. Model Data Sharing Tool currently developed at IRD). Procedure of data export could finally be developed in collaboration with ICCAT to comply with the standard referentials of the ICCAT databases.

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Table 1. Number of Ghanaian active fishing vessels as recorded in the landings (Ntrip) and logbooks (Nactivity) during 2006-2012.

YearC	*GearGrp*	*Ntrip*	*Nactivity*
2006	BB	20	19
2007	BB	2	6
2008	BB	19	19
2009	BB	19	19
2010	BB	20	19
2011	BB	15	15
2012	BB	14	14
2006	PS	10	7
2007	PS	2	3
2008	PS	9	7
2009	PS	12	12
2010	PS	16	12
2011	PS	16	12
2012	PS	16	16

Table 2. Total catch (t) declared in the logbooks for the PANOFI and other Ghanaian PS during 2006-2012.

Year	*P-Fleet*	*A-Fleet*	*ALL*
2006	659	13749	14408
2007	0	4361	4361
2008	505	18040	18545
2009	5444	35533	40977
2010	945	35833	36778
2011	1761	27629	29390
2012	27266	26786	54052

Table 3. Total landings (t) recorded for the PANOFI and other Ghanaian PS during 2006-2012. Information on PANOFI landings was not fully included in AVDTH database and provided through an alternative data source.

Year	*PANOFI*	*OTHERS*	*ALL*
2006	25952	19348	45300
2007	20457	0	20457
2008	16909	21714	38623
2009	17472	30786	48258
2010	33153	28386	61539
2011	32397	21608	54005
2012	28721	23796	52517

Table 4. Total nominal catch of the Ghanaian baitboats (BB) and purse seiners (PS) from the current ICCAT Task I, the cumulated catches declared in the logbooks, and the cumulated landings recorded at unloading. Proposal = maximum value of total catch proposed, Change = % change between current ICCAT and proposed total catch, Source = Origin of the proposed total task I.

YearC	*GearGrp*	*ICCAT*	*Catches*	*Landings*	*Proposal*	*Change*	*Source*
2006	BB	28972	31062	28972	31062	+7.2%	Logbooks
2007	BB	25501.63	3139	NA	25502	0	ICCAT
2008	BB	43932.36	22330	25259	43932	0	ICCAT
2009	BB	31125.74	27809	27284	31126	0	ICCAT
2010	BB	23884.75	22035	21733	23885	0	ICCAT
2011	BB	16410	24926	16574	24926	+51.9%	Logbooks
2012	BB	22864.3	23938	22812	23938	+4.7%	Logbooks
2006	PS	22703	14408	45300	45300	+99.5%	Landings
2007	PS	42249.38	4361	20457	42249	0	ICCAT
2008	PS	20162.22	18545	38623	38623	+91.6%	Landings
2009	PS	35344.26	40977	48258	48258	+36.5%	Landings
2010	PS	56335.37	36778	61539	61539	+9.2%	Landings
2011	PS	53394.5	29390	54005	54005	+1.1%	Landings
2012	PS	52465	54052	52517	54052	+3%	Logbooks

Table 5. Distribution of the new total task I for purse seiners between the P-fleet and the A-fleet. FP = Faux-Poisson landed in Abidjan.

Year	P-Fleet	A-Fleet	Task I	FP
2006	25952	19348	45300	7087
2007	20457	21792	42249	8211
2008	16909	21714	38623	9807
2009	17472	30786	48258	10552
2010	33153	28386	61539	12363
2011	32397	21608	54005	NA
2012	28721	23796	54052	10274

Table 6. Monthly percentage of catch derived from logbook data during 2006-2012. The percentage in 2007 was computed as the mean value from 2006 and 2008-2012.

YearC	Gear	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	BB	4.3	6.6	4.8	4.0	12.8	4.5	4.2	9.7	20.8	21.3	6.2	0.9
2007	BB	6.5	8.0	7.8	6.7	8.3	7.7	6.2	9.2	12.1	12.1	8.5	6.9
2008	BB	4.5	3.3	7.3	5.8	7.1	4.1	6.9	15.9	13.7	11.7	7.9	11.7
2009	BB	5.8	9.6	6.5	5.4	6.3	17.4	8.0	9.0	8.6	9.8	6.5	7.0
2010	BB	8.9	9.2	9.5	7.1	8.7	6.6	3.8	8.4	10.8	10.1	8.1	8.7
2011	BB	4.3	13.8	9.7	11.1	9.1	7.6	4.1	3.9	5.2	10.8	10.8	9.7
2012	BB	11.4	5.5	8.8	6.9	6.1	5.8	9.9	8.5	13.5	8.8	11.5	3.3
2006	PS	12.3	9.2	10.0	7.1	10.2	6.9	5.1	6.8	10.0	9.8	8.8	3.8
2007	PS	8.9	9.6	8.3	7.0	8.7	6.2	6.5	9.0	10.3	9.6	8.3	7.5
2008	PS	11.5	7.4	5.4	6.0	7.1	8.3	6.9	6.9	13.6	14.2	5.2	7.5
2009	PS	4.2	9.6	6.5	8.1	9.3	5.7	11.4	12.1	11.9	7.5	5.0	8.7
2010	PS	8.7	10.2	12.2	7.0	8.3	5.3	4.1	10.4	8.2	8.7	7.6	9.3
2011	PS	10.2	15.6	10.2	8.6	7.2	4.3	3.4	8.6	4.3	7.2	9.5	10.9
2012	PS	6.7	5.5	5.4	5.5	9.9	6.9	8.1	9.1	13.9	10.5	13.8	4.8

Table 7. Annual catch by gear, fleet, and species for the Ghanaian fisheries derived from the data processing.

YearC	Flag	Gear	Fleet	YFT	SKJ	BET	ALB	AUX	EUT	Total
2006	Ghana	BB	GHA	5501	20767	3435	0	1093	266	31062
2007	Ghana	BB	GHA	4302	17500	2142	1	835	722	25503
2008	Ghana	BB	GHA	10236	27741	4363	5	1020	568	43932
2009	Ghana	BB	GHA	6935	18807	3532	3	1067	782	31126
2010	Ghana	BB	GHA	4287	15778	2315	3	987	515	23885
2011	Ghana	BB	GHA	3453	18009	2242	0	795	324	24823
2012	Ghana	BB	GHA	3312	17865	1120	0	510	761	23568
2006	Ghana	PS	A-Fleet	3458	12835	2174	0	736	144	19347
2007	Ghana	PS	A-Fleet	3805	13877	1670	1	652	540	20544
2008	Ghana	PS	A-Fleet	4774	13703	2494	3	490	250	21714
2009	Ghana	PS	A-Fleet	5711	19245	4325	5	962	538	30786
2010	Ghana	PS	A-Fleet	4663	18160	4051	6	1045	461	28386
2011	Ghana	PS	A-Fleet	2546	14094	3603	0	506	233	20982
2012	Ghana	PS	A-Fleet	2729	17882	2098	0	628	458	23794
2006	Ghana	PS	P-Fleet	4515	17337	2962	0	983	154	25952
2007	Ghana	PS	P-Fleet	2905	14376	2034	2	674	468	20459
2008	Ghana	PS	P-Fleet	3642	10647	2071	3	371	176	16909
2009	Ghana	PS	P-Fleet	3387	10728	2553	3	509	292	17472
2010	Ghana	PS	P-Fleet	5121	21368	4932	8	1245	479	33153
2011	Ghana	PS	P-Fleet	3854	22121	5218	0	870	334	32397
2012	Ghana	PS	P-Fleet	3072	21537	2865	0	796	448	28718

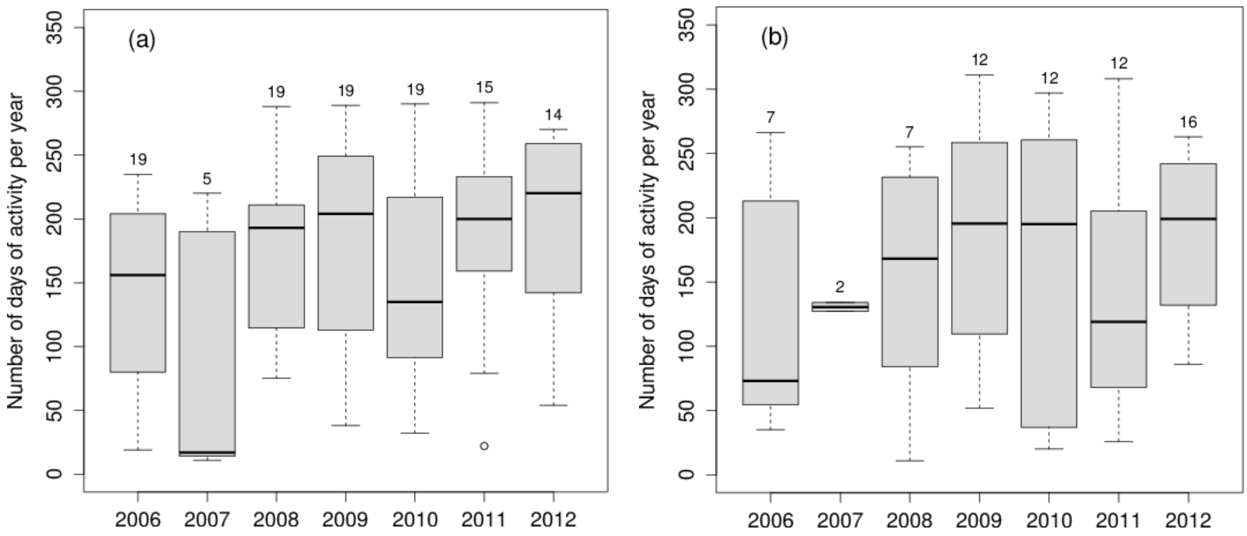

Figure 1. Number of days of activity with catch per vessel as recorded in the logbooks during 2006-2012 for (a) baitboats and (b) purse seiners. Number above the boxplot indicates the number of vessels for which data is available.

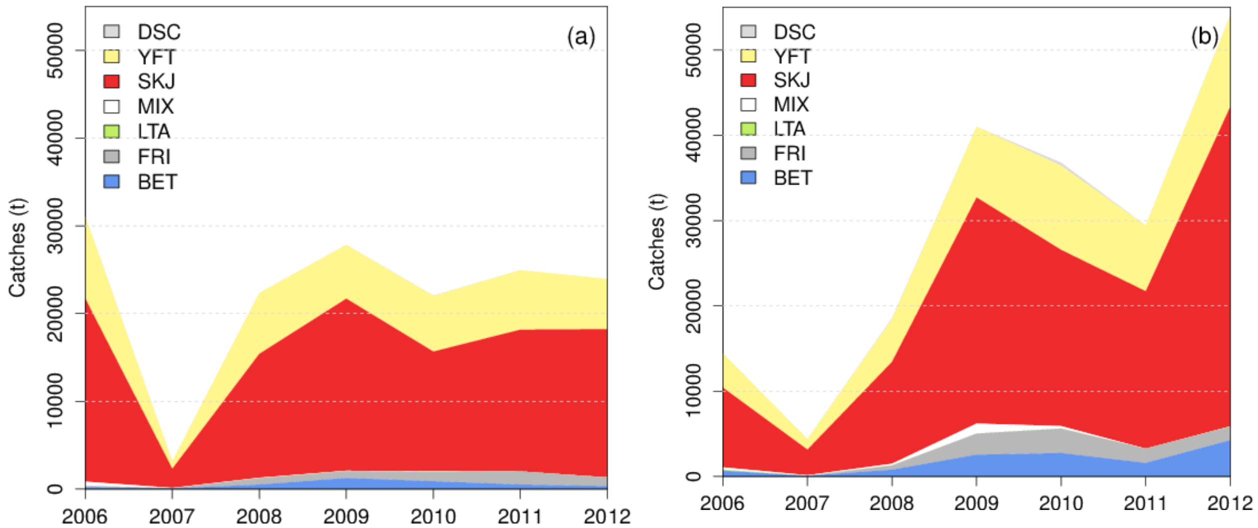

Figure 2. Annual cumulated catch by species as recorded in the logbooks during 2006-2012 for (a) baitboats and (b) purse seiners.

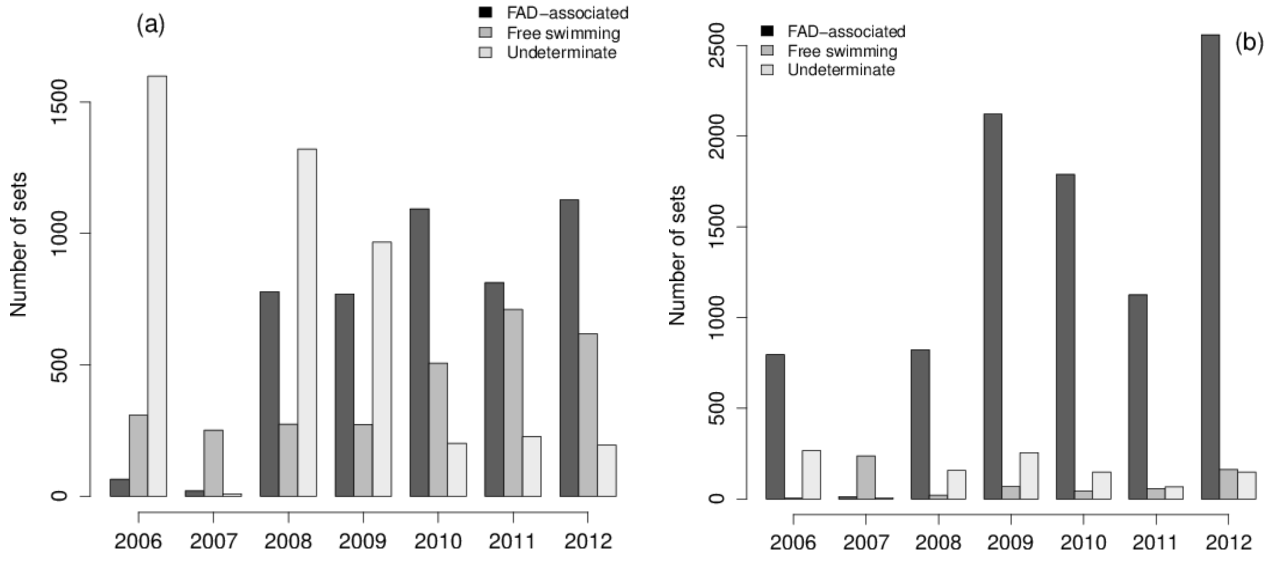

Figure 3. Annual number of fishing sets by fishing mode derived from logbooks of (a) baitboats and (b) purse seiners.

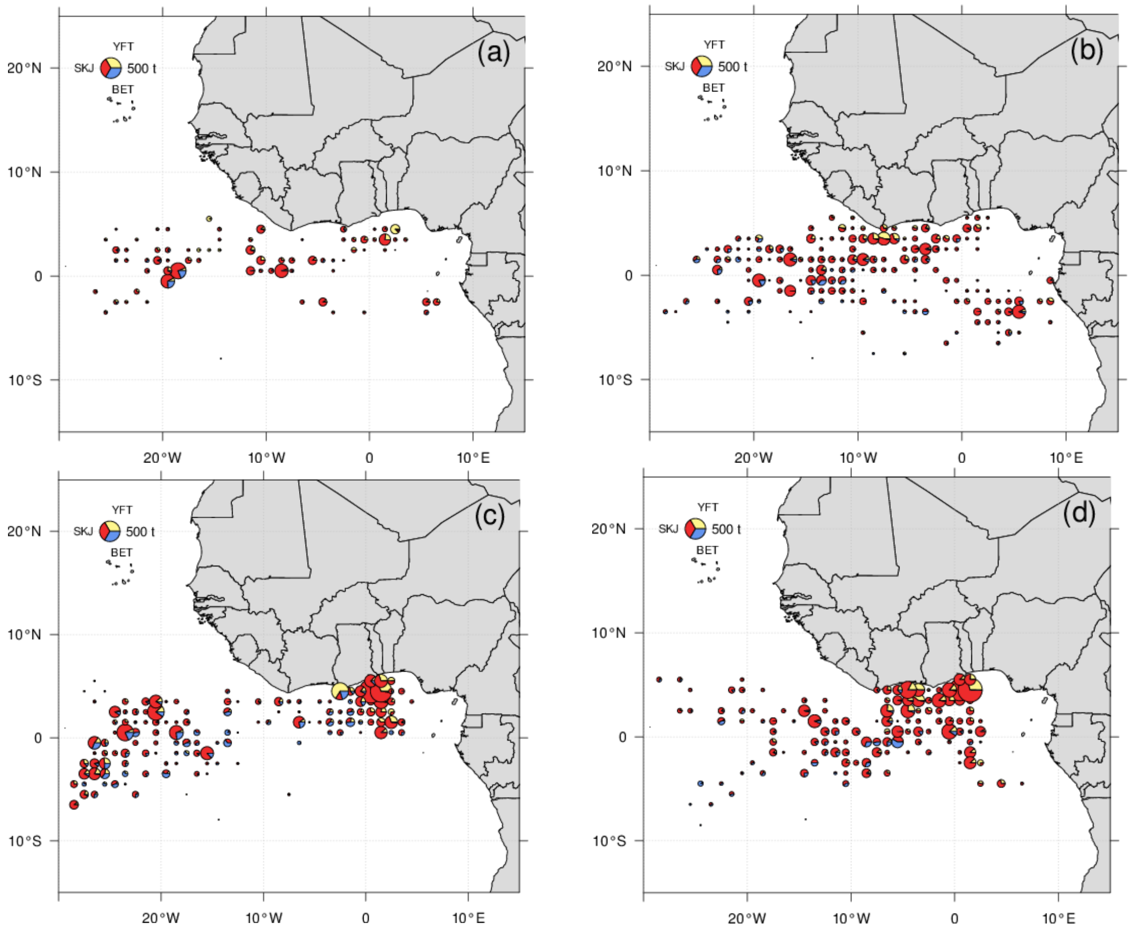

Figure 4. Quarterly spatial distribution of the catch of principal market tunas for the P-fleet (PANOFI) in 2012: (a) Jan-Mar, (b) Apr-Jun, (c) Jul-Sep, (d) Oct-Dec

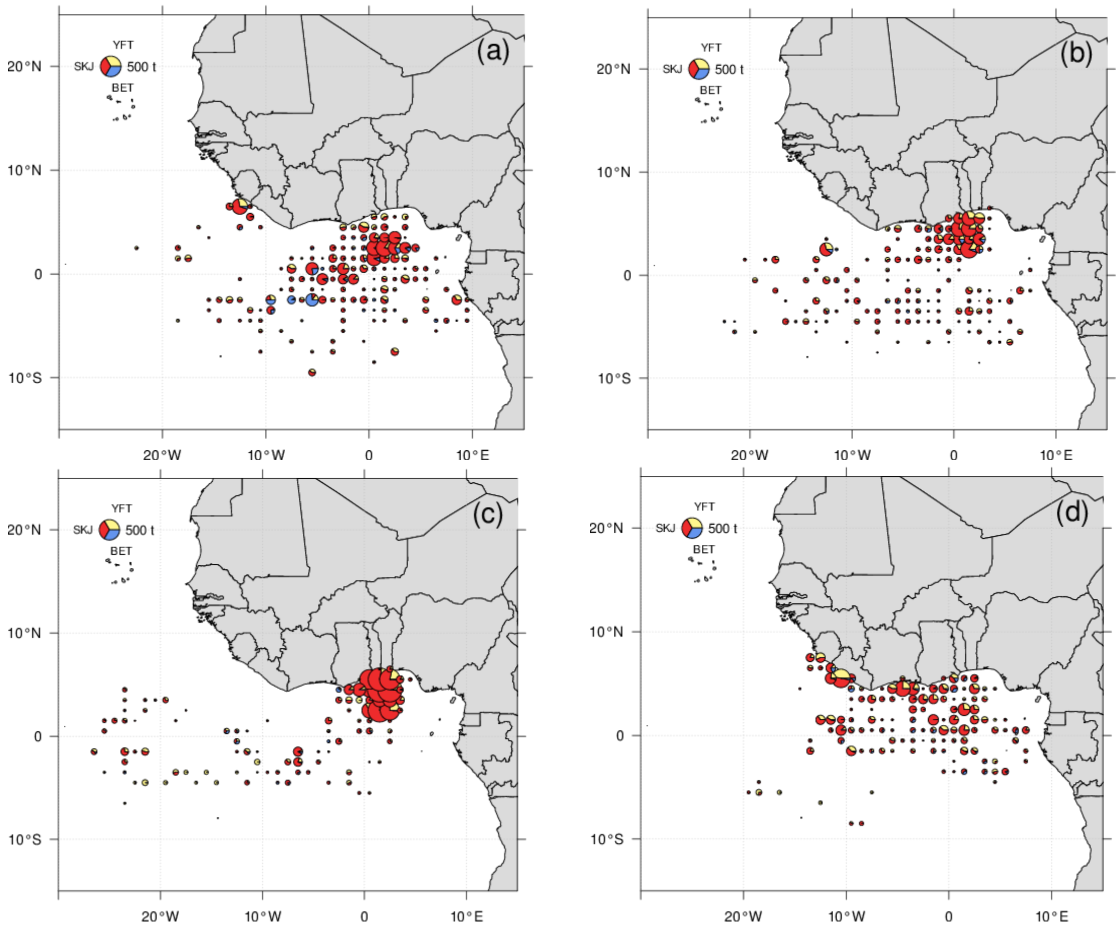

Figure 5. Quarterly spatial distribution of the catch of principal market tunas for the A-fleet (Others than PANOFI) in 2012: (a) Jan-Mar, (b) Apr-Jun, (c) Jul-Sep, (d) Oct-Dec.

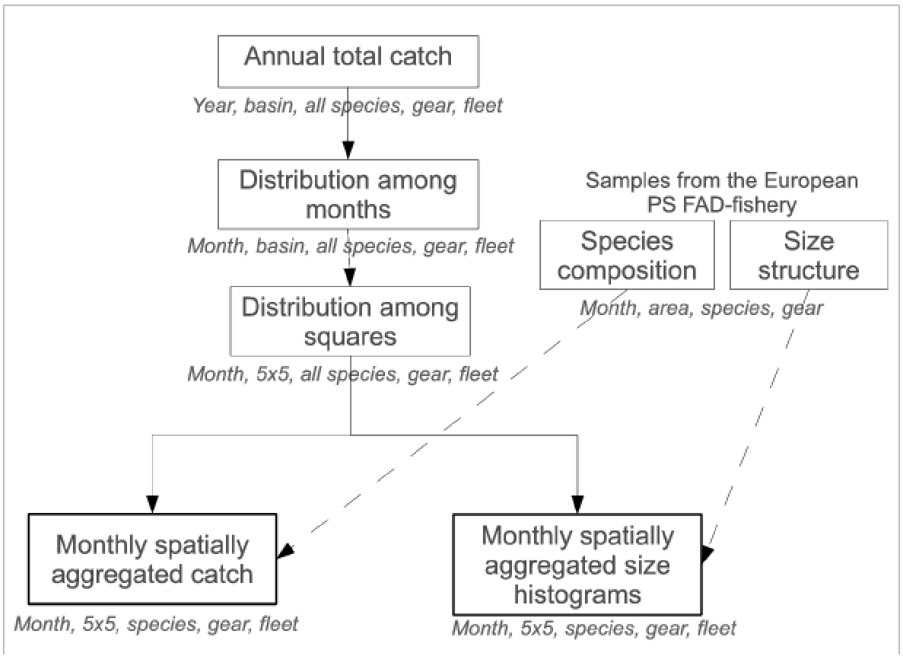

Figure 6. Steps of the processing of Ghanaian industrial tuna fisheries data. The temporal, spatial, and technical resolution is given for each step

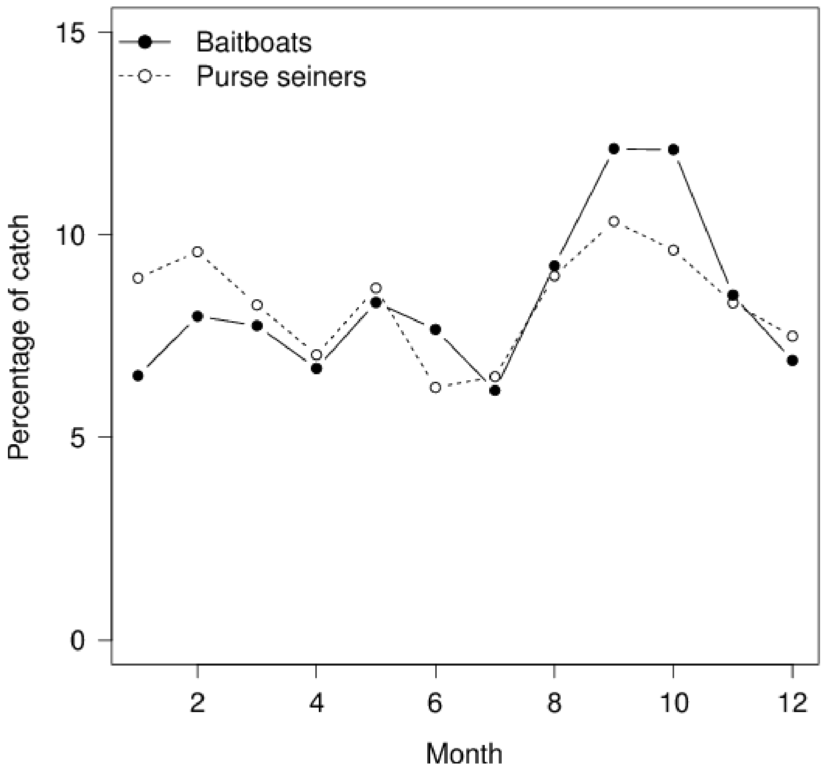

Figure 7. Average monthly percentage of annual catch for each fishing gear during 2006-2012. The year 2007 was not included as the logbooks represented about 11% of the total Task I for this year.

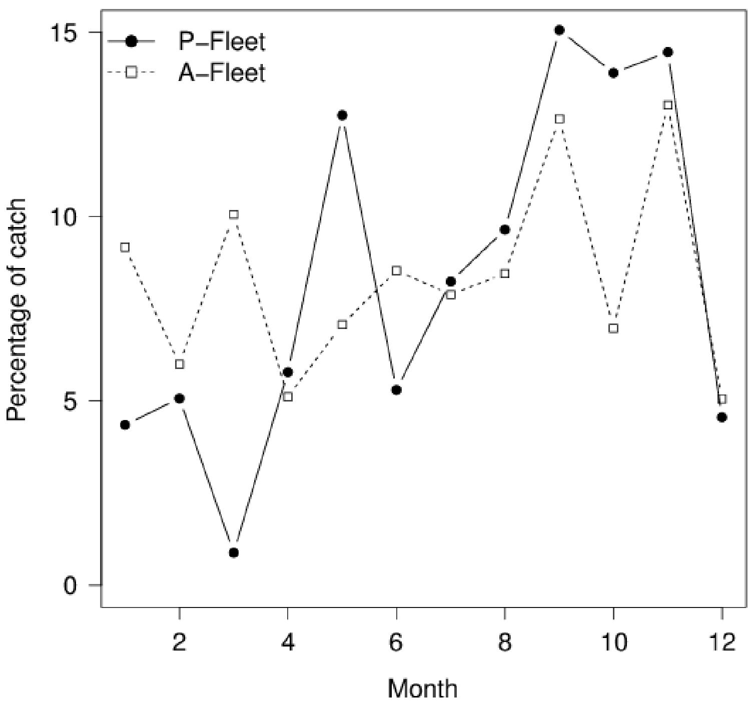

Figure 8. Monthly percentage of annual catch in 2012 for the PANOFI vessels (P-Fleet) and the rest of the Ghanaian PS fleet (A-Fleet)

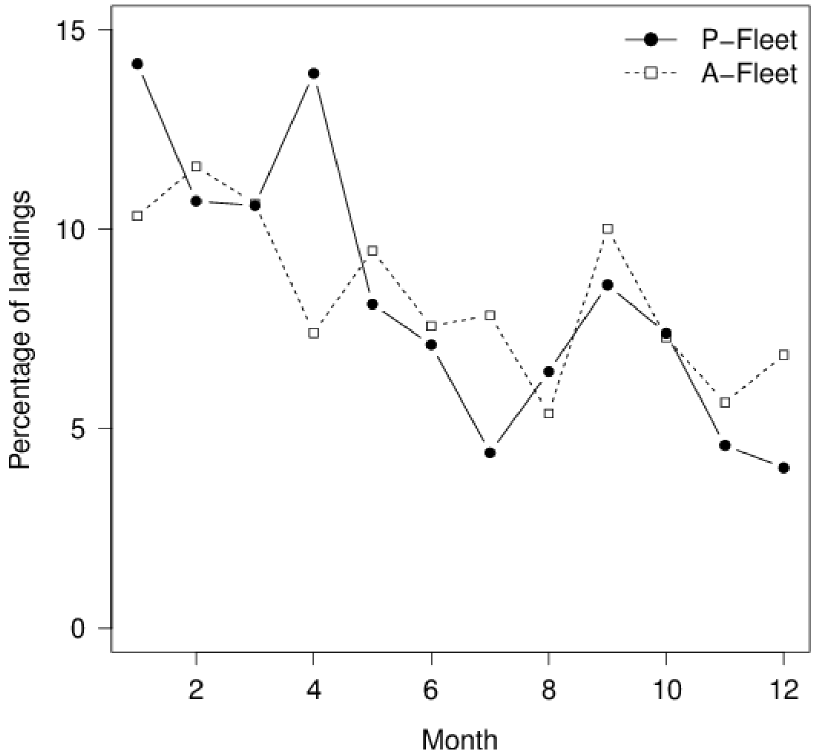

Figure 9. Average monthly percentage of annual landings during 2008-2011 for the PANOFI vessels (P-Fleet) and the rest of the Ghanaian PS fleet (A-Fleet).

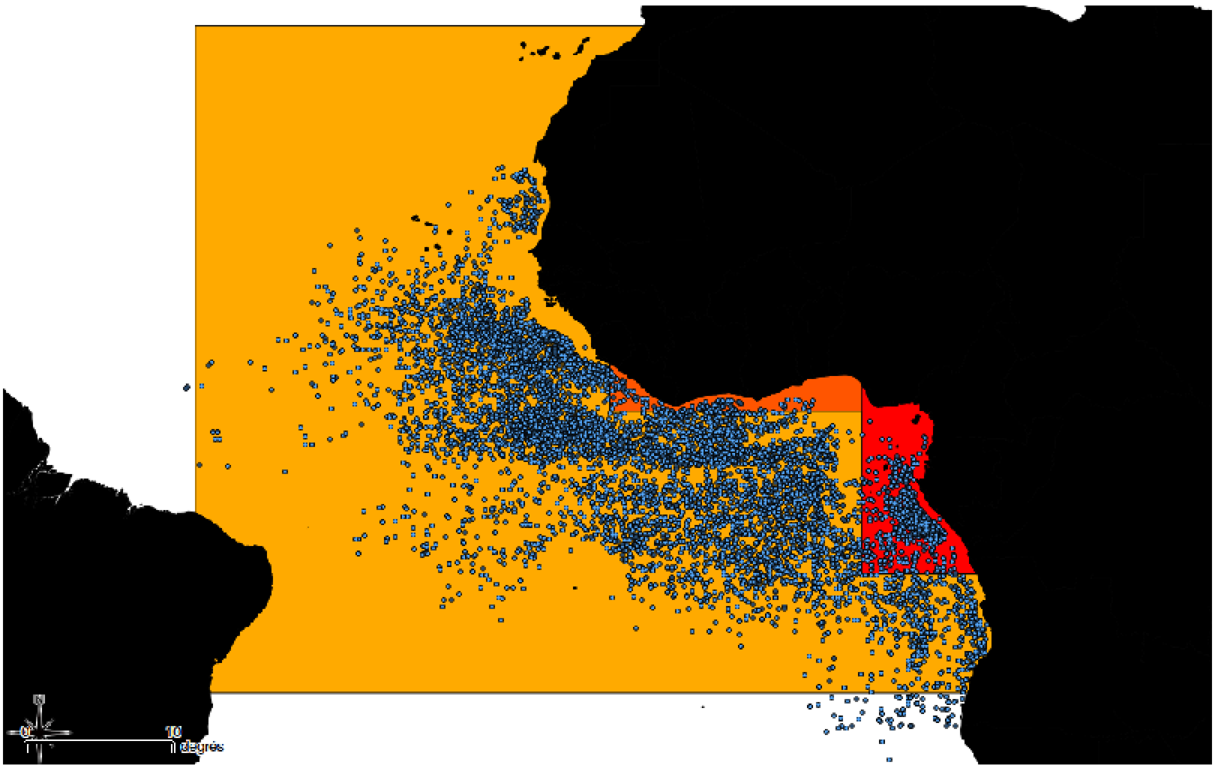

Figure 10. Location of the size-frequency samples (blue points) collected from the European purse seine fishery during 2006-2012. The 3 stratification areas are indicated with colors: (i) Coasts of Ivory coast and Ghana (dark orange), (ii) Cape Lopez area (red), and (iii) offshore area (light orange).

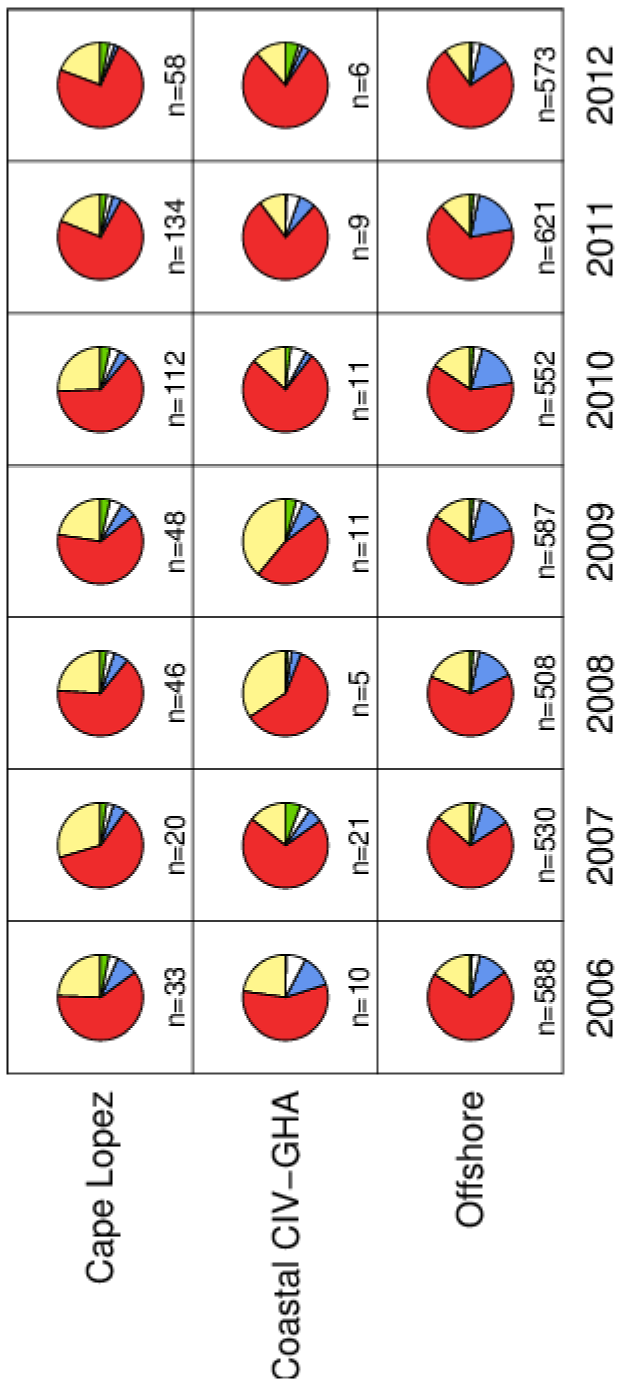

Figure 11. Annual species composition by spatial stratum derived from the size-samples of the European purse seine fishery on FAD-associated schools during 2006-2012. red = *Katsuwonus pelamis*, yellow=*Thunnus albacares*, blue = *Thunnus obesus*, green = *Euthynnus* spp., white = *Auxis* spp., black = *Thunnus alalunga*

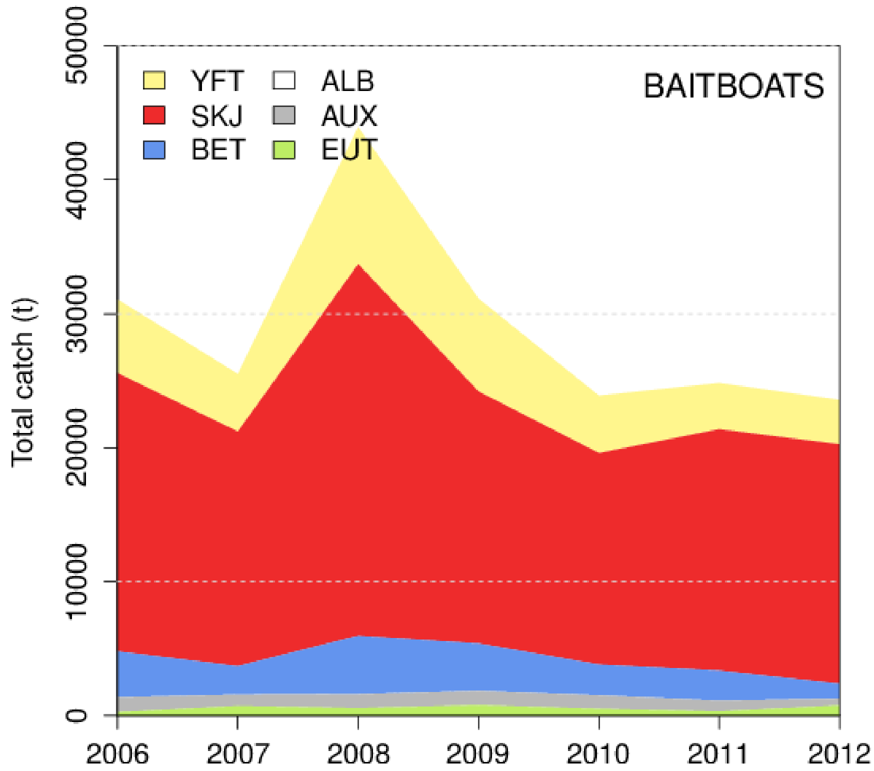

Figure 12. Annual cumulated catch (t) by species of the Ghanaian baiboats during 2006-2012 as derived from the data processing.

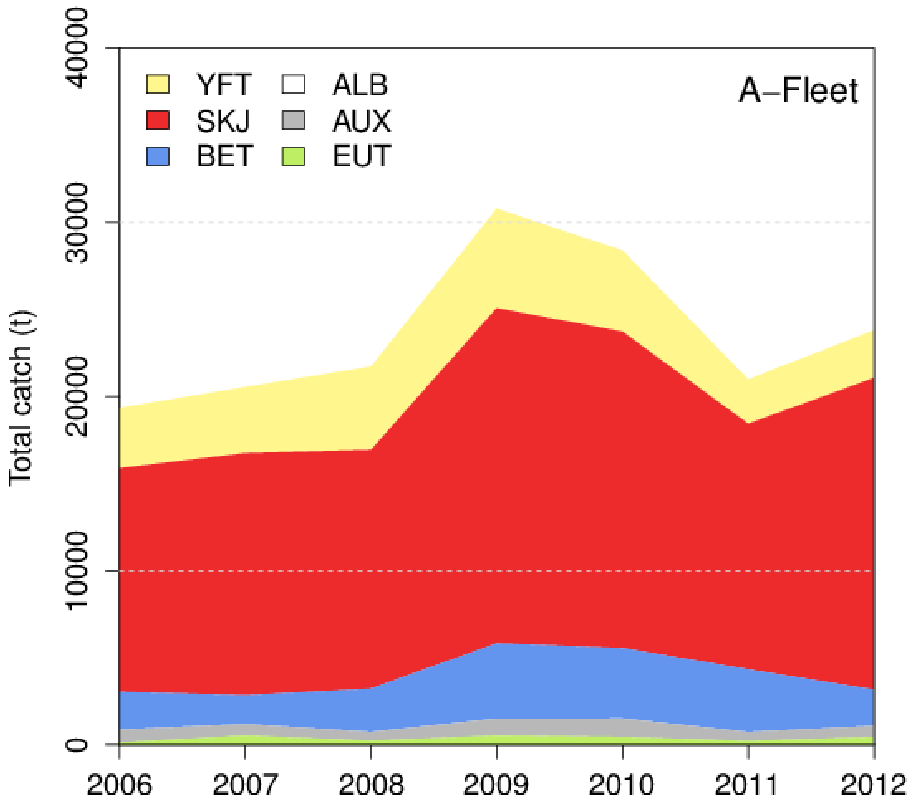

Figure 13. Annual cumulated catch (t) by species of the Ghanaian A-Fleet of purse seiners during 2006-2012 as derived from the data processing

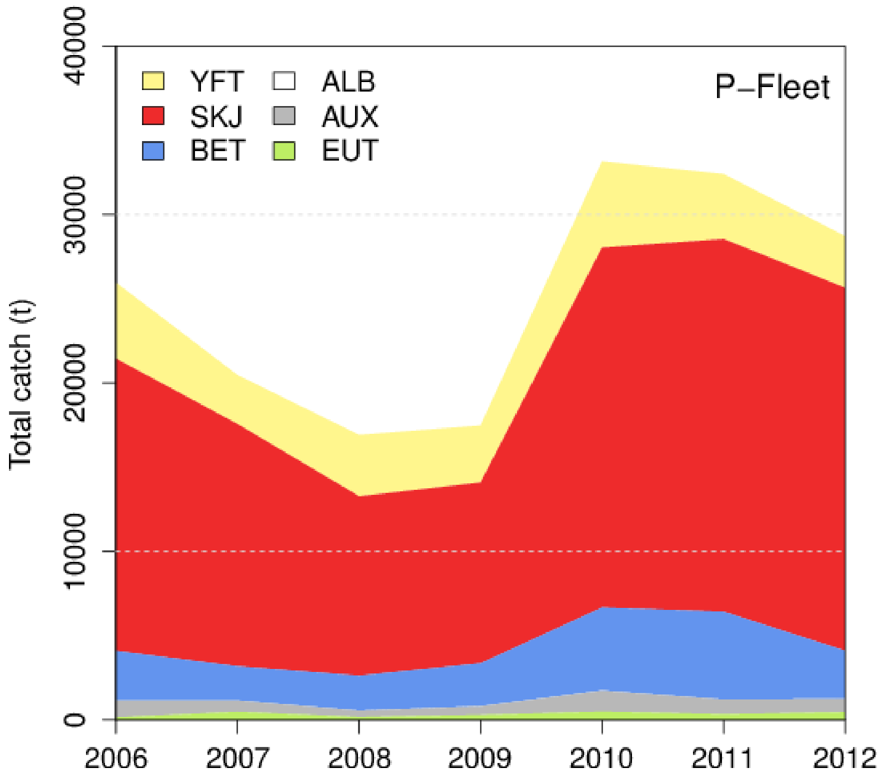

Figure 14. Annual cumulated catch (t) by species of the Ghanaian P-Fleet of purse seiners during 2006-2012 as derived from the data processing.

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SIMULATING TAGGING OF TROPICAL TUNA IN THE EQUATORIAL ATLANTIC OCEAN

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SUMMARY

Simulations were conducted to study the bias and precision of estimates of natural mortality and catchability for a hypothetical tagging p rogram of the three species of Atlantic tropical tuna, yellowfin tuna, bigeye tuna and skipjack. Different scenarios of the mix of species and number of tuna released were considered. Scenarios considered whether priority was given to the species of greatest concern regarding stock status, the species of greatest uncertainty in population parameter estimates, whether the species were tagged according to the proportion caught in the Ghana baitboat fleet or whether the same numbers of tuna were tagged for the three species. Results suggest that estimates of these parameters, given model assumptions, would be asymptotically unbiased and relatively precise regardless of the tagging scenario. There is, however, at least a 20% probability that an individual tagging program would result in estimates of bias of about 15% percent of more, even under the strict assumptions considered here. There is a need to investigate the effect on estimates of these parameters caused by the failure of other model assumptions not yet investigated.

RÉSUMÉ

Des simulations ont été réalisées pour étudier les biais et la précision des estimations de la mortalité naturelle et de la capturabilité pour un programme de marquage hypothétique des trois espèces de thonidés tropicaux de l'Atlantique : albacore, thon obèse et listao. On a considéré différents scénarios du mélange des espèces et du nombre de thons remis à l'eau. Les scénarios ont considéré si la priorité était accordée aux espèces dont l'état du stock suscite le plus de préoccupation, aux espèces faisant l'objet de la plus grande incertitude dans les estimations des paramètres de population, si les espèces ont été marquées selon la proportion capturée dans la flottille de canneurs ghanéens ou si le même nombre de thons ont été marqués pour les trois espèces. Les résultats suggèrent que les estimations de ces paramètres, compte tenu des postulats du modèle, seraient asymptotiquement non biaisées et relativement précises indépendamment du scénario de marquage. Il existe toutefois 20% de probabilité qu'un programme de marquage individuel entraîne des estimations de biais d'environ 15% ou plus, même en vertu des stricts postulats examinés dans le présent document. Il faut chercher à déterminer l'effet sur les estimations de ces paramètres causés par la défaillance d'autres postulats du modèle qui n'ont pas encore été étudiés.

RESUMEN

Se realizaron simulaciones para estudiar el sesgo y la precisión de las estimaciones de mortalidad natural y capturabilidad para un programa de marcado hipotético de las tres especies de túnidos tropicales del Atlántico: rabil, patudo y listado. Se consideraron diferentes escenarios de la mezcla de especies y número de túnidos liberados. Se consideraron los siguientes escenarios de marcado: asignar prioridad a las especies que generan más preocupación en lo que concierne al estado del stock, asignar prioridad a las especies para las que existe mayor incertidumbre sobre las estimaciones de parámetros de población, considerar el marcado de especies en función de la proporción capturada en la flota de cañeros de Ghana o el marcado del mismo número de ejemplares para las tres especies. Los resultados sugieren que las estimaciones de estos parámetros, datos los supuestos del modelo, serían asintóticas, no sesgadas y relativamente precisas al margen del escenario de marcado. Sin embargo, existe una probabilidad de al menos el 20% de que el programa de marcado individual tenga como

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resultado estimaciones de sesgo de aproximadamente el 15% o más, incluso bajo los supuestos más estrictos considerados aquí. Es necesario investigar el efecto causado en las estimaciones de estos parámetros por los errores de otros supuestos del modelo que no se han investigado todavía.

KEYWORDS

Abundance, Bait fishing, Exploitation, Fishing mortality, Long lining, Multispecies fisheries, Natural mortality, Population dynamics, Purse seining, Simulation, Stock assessment, Stochastic models, Tagging

1 Introduction

For the last few years, the ICCAT SCRS has been considering the possibility of conducting a large-scale tagging program on tropical tunas (Anonymous 2013) similar to those conducted before in the Western Pacific where 146,000 tunas were tagged and 18,500 recaptured as part of the SPC Regional Tagging Program (SPC 2013) and Indian Ocean where more than 168,000 tunas were tagged and 27,000 recaptured as part of the IOTC Regional Tuna Tagging Program (IOTC 2012). Foremost among the objectives of such program is the goal to improve population parameters that are important for the evaluation of stock status for bigeye tuna (*Thnunnus obesus)*, yellowfin tuna (*Thunnus albacores)* and skipjack (*Katsuwonus pelamis)*. Such parameters may include growth, survival and migration rates and the catchability of various fleets. Although, in theory, all these parameters are estimable from tagging data the success of a tagging program largely rests on the combination of 1) having an appropriate methodological design for the goals of the program, 2) properly implementing this design on the field and 3) obtaining the collaboration of the fishing industry for the reporting of accurate information on tag returns.

In this study we aim to develop a simulation tool that can help define selected aspects of the methodological design for the tagging program. This simulation tool addresses the following question: what are some of the tradeoffs that a program like this may have to consider because the three species that are objective of the program are often caught together and thus may be tagged, released and recapture together? More specifically we ask about the ability of such a program to obtain estimates of population parameters for the three species and the uncertainty associated with such estimates. In the study we make the assumption that tag and release will be conducted from baitboat(s) and that the all the recaptures would come from the purse seine fleet. These assumptions reflect the tagging program that was implemented in the Indian Ocean. Furthermore, in the simulations we assume that the tagging would take place in the Eastern Equatorial Atlantic on a survey vessel with similar selectivity to that of the baitboat fleet of Dakar with recoveries been mostly reported by the purse seine fleets from Ghana and the European Union (Gaertner et al. 2004, Hallier and Gaertner 2006).

The simulation model used is a modification of the model proposed by Lauretta (2013) to evaluate estimation bias in a single species framework. The main modifications were 1) change simulation parameters to mirror the scale of abundance of populations of the three species found in the Equatorial Atlantic and, 2) capture and recapture the three species simultaneously. In the study we evaluate the consequences of making different choices on the ratios of tagged animals for the different species caught by the baiboat. Such choices on the number of tuna released with tags from each of the three species are critical to the design of the program, because while migration and growth rates are generally estimable even with few tag returns, much higher numbers of tag returns are necessary to obtain mortality rate and catchability estimates that are relatively precise. By identifying the likely levels of uncertainty of the estimates of these parameters we hope that we can contribute to the design of a more successful tagging program.

2 Methods

A detailed explanation of the equations used in the single-species model can be found in Lauretta 2013, with a few changes described below to adjust for simulating three species simultaneously (**Table 1**). Assumptions of the simulation presented here are the same as those in Lauretta (2013), however, in this study we explore different scenarios of the number of animals tagged with conventional tags from each species because our focus is on the estimation of mortality rates and catchability. As in Lauretta's (2013), the model also incorporates

PSAT releases and high reward tags to estimate migration and reporting rates, but in this study we do not explore tradeoffs for those other two types of tags. For those interested in such tradeoffs, please see Lauretta (2013). As was done by Lauretta (2013) we ran 10,000 simulations for each test scenario.

Four different tagging scenarios were tested using three different tagging effort levels (**Table 2** and **Table 3**). The 'baitboat' scenario tags fish in the same proportion as they are caught in the baitboat fishery, i.e. every fish caught is tagged regardless of species, based upon the distribution of catch in the Dakar baitboat fishery (Gaertner et al. 2004). The 'even' scenario tags an equal number of all three fish. The 'uncertainty' scenario tags fish based upon the level of uncertainty in population estimates in a ratio of 3:2:1 for SKJ:BET:YFT. This scenario assumes that the highest uncertainty in population parameters is for skipjack, and the least amount of uncertainty is associated with yellowfin tuna. The 'concern' scenario tags fish in a ratio of 1:2:3 for SKJ:BET:YFT. It assumes that ratios of releases should aim to improve population parameters on ratio that reflects the level of concern on stock status for each species because species on a less favorable status would benefit more from improvements in population parameters. In this scenario we assume that the greatest concern is for yellowfin tuna and the lowest concern for skipjack. These scenarios only apply to the usage of conventional tags. The numbers of PSAT and high reward tags are evenly distributed among all three species for all tagging scenarios. The tagging effort level is divided into high, medium, and low, with the high level of effort set equal to the approximate number of fish tagged during the Indian Ocean Tuna Tagging program (Eveson et al. 2012), which at this stage is considered to reflect an optimistic scenario. As a result these simulations represent scenarios where the number of skipjack and yellowfin tuna tagged ranged from 8,350 to 100,000 fish, but the number of bigeye tuna ranged between 11,500 to 66,000 (**Table 3**). Note that the only scenario where the number of tagged bigeye tuna is substantially different to the others is scenario "baitboat".

Catchability and natural mortality rates used in the simulation were those estimated on the latest stock assessment reports for each species (**Table 1**). Catchability estimates reported in stock assessments were from catch in biomass, and so were converted to numbers of fish for the age classes we are most likely to catch and tag using the relative catch in biomass and abundance in numbers of fish. Ages ranges of tuna released and recaptured were assumed to be similar to those tagged in the Indian Ocean Tuna Tagging program (Eveson et al. 2012). Skipjack would be tagged at ages 0-2, yellowfin tuna at ages 1-2, and bigeye tuna at ages 0-2. Given that we assume that the duration of the simulated recapture program is three years, the oldest ages recovered would be age 5. As a result, in the simulation, catchability estimates correspond to ages 0-5.

Fishing effort levels represent a range that would produce levels of fishing mortality similar to those estimated during the most recent stock assessments of each species (Anonymous 2008, 2011, 2012). Tag shedding was assumed to correspond only to type-1 tag loss as estimated from previous tagging studies (BET: Gaertner et al., 2004; SKJ: Kleiber et al., 1987, Adam and Kirkwoor 2001).

The simulation aims to portray populations in two geographic regions. These two regions are both to the east of 30°W, thus only the eastern stock of skipjack is included in this simulation. Region 1 covers the southern equatorial Atlantic area south of 10°N including fisheries in the Gulf of Guinea. Region 2 covers the northeastern Atlantic north of 10°N including fisheries from the Azores, Senegal, and Cape Verde Islands. Migration between the two regions was assumed to be instantaneous and was estimated based upon the relative catch in biomass of each species in the two regions. Yellowfin tuna are primarily caught in the equatorial region with little biomass in the northern region, thus migration rates between the two regions are small. Assuming the majority of all three species spawn in region 1, the majority of the fish caught in region 2 would have migrated there (Pallares et al. 2005, ICCAT 2006-2013). A larger proportion of bigeye tuna are caught in this region than skipjack, however bigeye tuna have a much longer lifespan and thus have more time to build up biomass in the region. Therefore skipjack have the highest migration rate from region 1 to region 2 (m_{12}) estimated as half of the natural mortality rate, followed then by bigeye tuna with approximately half the migration rate of skipjack. The migration rates from region 2 to region 1 (m_{21}) are assumed to be small and were estimated as 25% of m_{12}.

3 Results

For each simulation we calculated the bias as the difference between the value of the parameters used in the simulation and the estimate obtained. Bias was calculated for natural mortality rate and the catchability of the purse seine. From the 10,000 values of bias calculated for each scenario the following statistics are reported: median, 2.5, 10, 25, 75, 90 and 97.5 percentiles. Additionally we report the standard error of the values of natural mortality rate and catchability (**Tables 4-6**).

As expected the standard error of mortality rate and catchability decrease (precision of these estimates increases), as the number of tags increases for an individual species. When all scenarios are considered the maximum standard error in natural mortality are 0.13 and 0.14 for the yellowfin tuna and bigeye tuna respectively when low effort is used and tuna are tagged according to the “uncertainty scenario”. The maximum standard error in natural mortality estimates of skipjack is 0.11 for the low tagging effort and the “concern scenario”. A similar result was obtained regarding the precision of estimates of catchability. Maximum CVs were obtained for yellowfin tuna (0.15) and bigeye tuna (0.14) when the “uncertainty” scenario was used and for skipjack (0.12) for the “concern” scenario.

The median bias in estimates of mortality rates and catchability was low in all scenarios never exceeding more than half a percent. This asymptotic property of the estimator is expected and confirms the estimators are unbiased. Ninety five percentiles of these distributions, however, include some large biases in the estimates reaching +28% to -24% for natural mortality and +36% to -25% in catchability for yellowfin tuna. Similar numbers for bigeye tuna are +28% to -26% for natural mortality and +26% and -20% for catchability. Finally, for skipjack, the numbers are +13% to -13% for natural mortality and +17% and -15% for catchability. As reported above, the less precise estimates are obtained for low tagging effort and the “uncertainty” scenario for yellowfin tuna and bigeye tuna and for the “concern” scenario for skipjack.

It is also important to remember that the median only represents the central tendency of the bias in the asymptotic case; that is if the tagging program was conducted many times. Any single implementation of the tagging program could result in biases within the distributions displayed in **Figures 1-9**. A useful measure of how likely it would be to have a severe bias is to look at the biases for the 90^{th} and 10^{th} percentiles. For yellowfin tuna we see that there is a 20% probability that the bias for a single implementation of the program would exceed about 10%, depending on the scenario of tagging considered. For instance, if the tagging scenario “uncertainty” with low effort was implemented there would be a 20% probability that the bias in natural mortality would exceed ±~15%. Similarly, if the tagging scenario “uncertainty” with low effort was implemented there would be a 20% probability that the bias natural mortality would exceed ±~18% for bigeye tuna. Finally, if the tagging scenario “concern” with low effort was implemented there would be a 20% probability that the bias natural mortality would exceed ±~8% for skipjack tuna.

4 Discussion and limitations of the model

Caruthers et al (2010) used a simulation model to test whether catch per unit of effort (CPUE) data from tropical tuna fleets can be used to estimate relative abundance of bigeye tuna and yellowfin tuna. They suggest that it is challenging to use such data for the purposes of stock assessment because the CPUE data usually available for these two species needs to be aggregated over large spatial scales for analysis and that data imputation may be a better option than aggregation. Their study, however demonstrated the power of simulation modelling as a tool to test the power of current statistical procedures in support of assessments of tropical tunas.

Our paper aimed to used simulation in a similar way than Caruthers et al 2010, but this time to help design and alternative information source for the assessment of tropical tunas, a large tagging program. The results presented suggest that a tagging design in which the proportion of fish tagged from each species is approximately even would result in the lowest bias for natural mortality and catchability estimates for all three species. The baitboat and even scenarios tended to produce smaller median bias for both parameters whereas the less evenly distributed scenarios, “concern” and “uncertainty”, tended to have larger median biases for the species which received fewer tags. Estimates of bias are smallest for skipjack due to the fact that skipjack catchability and natural mortality were assumed to be the highest for the three species.

The model, however, has limitations which may have led our simulations to overestimate tag recovery rates, and therefore underestimate bias. First, the proportion of catch for each species changes between the tagging fleet (baitboats) and the recovery fleet (purse seines) influencing the probability of recapture for each species. The current model assumes that recapture effort is evenly distributed among the three species and that the fishing mortality is therefore simply the product of effort and catchability. Generally, the purse seine fishery in the eastern Atlantic catches a higher proportion of skipjack and fewer yellowfin tuna and bigeye tuna than the baitboat fishery (Fonteneau et al. 2000, Hallier and Delgado de Molina 2000, Gaertner et al. 2004). This is partially due to a vertical stratification of species under FADs, with bigeye tuna often found deepest in the water column (Lennert-Cody et al. 2008). A more accurate estimate may be to set fishing mortality for the recoveries to approximate the fishing mortality generated by the purse seine fleet alone. Although this value is estimated by ICCAT for yellowfin tuna and bigeye tuna because they use fleet and age structured assessment models for these stocks, it is not available for skipjack. It may be possible to calculate this by apportioning mortality of skipjack as a proportion of the catch of each fleet under the assumption that there are no differences in fishing mortality at age.

There is a second reason why our estimates of bias may be inaccurate. Our model does not account for the effects of differential selectivity at age. We expect that the probability of capture decreases with age for bigeye tuna, and to a lesser extent, for yellowfin tuna over the ranges of ages being tagged and recaptured. For example, we know that bigeye tuna generally leave the surface fisheries and are exclusively caught in the long line fisheries when they become adults, or around ages 2-3 (Fonteneau and Pallares 2005). If bigeye tuna are tagged at ages 0-2 we could expect that as fish age over the course of the three-year study their probability of recapture by the purse seine fishery would decrease. This decrease in recapture probability with age causes the simulation to generally overestimate tag recoveries of older fish thus giving an overly optimistic estimate of bias. We would expect some decrease in the probability of recapture of tagged yellowfin tuna, also as they age, although not to the same extent as bigeye tuna.

On the other hand we do not consider at all the possibility of having tag recoveries in the baitboat or longline fisheries. In our model we assume all recoveries come from the purse seine fleet like it was the case in the Indian Ocean. In our model, however, we chose to be conservative in the reporting rate and chose a value of 10%, much lower than the 90% value reported for purse seiners in the Indian Ocean. The result is that simulated recapture rates in our experiments were around 3% (**Figure 10**), much lower than the 15% reported for the Indian Ocean. Although in the Indian Ocean the experience was that the majority of the recaptures were obtained in the purse seine fleet, we would hope that in the Atlantic we would manage to change that and obtain recaptures by these other fleets. If high reporting ratios of recovered tagged fish were achieved from these other fleets estimates of catchability for these fleets could be obtained and the natural mortality estimates could be further improved. More importantly high reporting rates from the longline fleet would ensure that the estimates of natural mortality rates could reflect older age classes, something that could not be obtained if we were to only rely on purse seine recoveries. Such high reporting rates for other fleets may be hard to achieve, especially if the estimates of historic reporting rates for the various Atlantic fleets provided by Caruthers and McAllister (2010) are accurate. In their paper these authors used observer data to calculate reporting rates in Atlantic tuna fleets and estimated, with few exceptions, reporting rates of less than 1.5 % and never greater than 5%. Reporting rates for several important Atlantic longline and baitboat fleets were less than 0.1% suggesting the job of increasing such rate to a meaningful value would be a very challenging one (Caruthers and McAllister 2010) and it may be more useful to focus all the tag recovery effort on the fleets were high reporting rates can be easily promoted with incentives or where reporting rates can be estimated with independent seeding experiments.

In summary, these results suggest that it would be possible to conduct a program for the three species of tropical tuna and obtain rather precise estimates of natural mortality and catchability for young fish (ages 0-5) with the levels of tagging effort considered in the simulation. It is important to remember, however, that these simulations assume some values of percentage of observer coverage and migration rates that have not been estimated for these Atlantic stocks. Moreover, the assumption we make that the probability of recapture is constant with age surely conditions our results. Spatial effects, such as heterogeneous distribution of effort and less than random distribution of release fish would also create departures from the assumption of our model and would have unknown consequences on the levels of bias associated with the estimates. We hope that, at least, this paper elicits discussions on alternative model structures or parameter values that should be investigated and simulated to help in the design of such tagging program, prior to the onset of field operations.

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Table 1. Parameter estimates used for each of the three tropical tuna species.

	Yellowfin Tuna	*Bigeye Tuna*	*Skipjack Tuna*
Natural Mortality (M)	0.7	0.4	0.8
Catchability coefficient (q)	0.0000017	0.0000012	0.0000032
Effort (E)	100000-200000	100000-200000	100000-200000
Fishing Mortality (F = qE)	0.17-0.34	0.12-0.24	0.32-0.64
Migration rate from Equatorial Region (1) to Northern Region (2) (m_{12})	0.05	0.2	0.4
Migration rate from Region 2 to Region 1 (m_{21})	0.05	0.05	0.1
Tagging/handling mortality (T)	0.15	0.1	0.1
Tag Shedding (s)	0.04	0.05	0.01
Observer Coverage/reporting rate region 1 (r_1)	0.1	0.1	0.1
Observer Coverage/reporting rate region 2 (r_2)	0.1	0.1	0.1

Table 2. Break down of tagging effort for each of the three levels, high, medium, and low.

Tagging Effort	*High*	*Med*	*Low*
Total conventional tags	200,000	100,000	50,000
Handling study tags	2000	1000	500
High reward tags/region	2000	1000	500
Electronic tags/Region	1000	500	250

Table 3. Proportion of conventional tags allocated for each species for the four tagging scenarios. In parenthesis number of tags for low and high tagging effort for each species (in thousands).

Tagging Scenario	*Baitboat*	*Even*	*q uncertainty*	*Concern*
SKJ	45% (22-90)	33% (16-66)	50% (25-100)	17% (8-33)
YFT	32% (16-64)	33% (16-66)	17% (8-33)	50% (25-100)
BET	23% (11-46)	34% (17-68)	33% (16-67)	33% (17-67)

Table 4. Biases in estimates of natural mortality and catchability and coefficients of variation for yellowfin tuna.

	Baitboat (23%)			*Even (33%)*			*Concern (50%)*			*Uncertainty in q (17%)*		
	High	*Med*	*Low*	*High*	*Med*	*Low*	*High*	*Med*	*Low*	*High*	*Med*	*Low*
Median % bias M	0.01	0.06	-0.33	0.08	0.13	-0.11	0.05	-0.05	0.11	-0.02	0.13	0.22
2.5 Percentile % bias M	-11.5	-15.2	-20.7	-9.9	-12.8	-17.2	-8.3	-11.1	-14.3	-13	-17.1	-23.8
10^{th} Percentile % bias M	-7.4	-9.9	-13.9	-6.3	-8.4	-11.4	-5.0	-7.2	-9.5	-8.1	-11.2	-16.0
25^{th} Percentile % bias M	-4.0	-5.2	-7.6	-3.1	-4.5	-6.2	-2.6	-3.9	-5.0	-4.3	-5.8	-8.5
75^{th} Percentile % bias M	4.1	5.6	7.5	3.6	4.7	6.3	2.8	3.9	5.5	4.4	6.2	9.2
90^{th} Percentile % bias M	7.8	10.4	14.7	6.8	9.0	12.4	5.3	7.4	10.4	8.5	12.1	17.5
97.5 Percentile % bias M	12.4	16.2	23.4	10.2	14.4	19.5	9	11.4	16	13.9	19.5	28
CV of M	0.06	0.08	0.11	0.05	0.07	0.09	0.05	0.06	0.08	0.07	0.09	0.13
Median % bias q	-0.27	-0.22	-0.24	-0.03	-0.17	-0.36	-0.1	-0.34	-0.27	-0.07	0.08	0.44
2.5 Percentile % bias q	-16.5	-18.5	-22.4	-15	-17.1	-20.4	-14.2	-15.5	-17.9	-16.8	-20.2	-25
10^{th} Percentile % bias q	-10.9	-12.7	-15.5	-10.3	-11.4	-13.9	-7.5	-10.7	-12.4	-9.0	-12.2	-17.5
25^{th} Percentile % bias q	-5.9	-7.0	-8.7	-5.6	-6.4	-7.7	-4.1	-6.0	-6.8	-4.9	-6.6	-9.6
75^{th} Percentile % bias q	5.6	7.1	9.3	5.2	6.3	8.0	4.0	5.6	6.9	5.2	7.8	11.3
90^{th} Percentile % bias q	11.3	14.3	19.07	10.4	12.2	16	8.0	11.2	13.5	10.2	15.0	22.7
97.5 Percentile % bias q	18.1	22.8	30.8	16.6	20.2	25.8	15.5	17.8	22.4	19.7	25.5	36.3
CV of q	0.09	0.1	0.13	0.08	0.1	0.12	0.08	0.08	0.1	0.09	0.12	0.15

Table 5. Biases in estimates of natural mortality and catchability and coefficients of variation for bigeye tuna.

	Baitboat (32%)			*Even (33%)*			*Concern (33%)*			*Uncertainty in q (33%)*		
	High	*Med*	*Low*	*High*	*Med*	*Low*	*High*	*Med*	*Low*	*High*	*Med*	*Low*
Median % bias M	0.03	-0.28	-0.07	0.08	-0.08	0.04	-0.08	-0.01	-0.11	-0.01	-0.11	-0.30
2.5 Percentile % bias M	-14.3	-18.8	-25.8	-14.2	-19.3	-26	-13.8	-18.9	-25.2	-14	-19	-25.5
10^{th} Percentile % bias M	-9.4	-12.8	-17.6	-9.1	-12.4	-17.4	-8.8	-12.2	-16.8	-8.8	-12.0	-17.5
25^{th} Percentile % bias M	-5.0	-6.88	-9.4	-4.8	-6.6	-9.6	-4.7	-6.6	-8.9	-4.7	-6.4	-9.4
75^{th} Percentile % bias M	5.1	6.58	9.4	5.2	6.8	9.0	4.8	6.7	9.1	4.6	6.5	9.4
90^{th} Percentile % bias M	9.7	12.8	18.1	9.7	12.9	17.6	9.0	12.8	17.6	8.8	12.5	18.3
97.5 Percentile % bias M	15	20	28.4	14.8	19.9	27	14.7	20.1	27.9	14.8	19.9	27.7
CV of M	0.08	0.1	0.14	0.08	0.1	0.14	0.08	0.1	0.14	0.07	0.11	0.14
Median % bias q	-0.35	0.34	-0.33	0.13	-0.07	-0.13	-0.20	-0.09	-0.47	0.01	0.1	-0.28
2.5 Percentile % bias q	-14.6	-17.1	-20.5	-14.1	-17.4	-20.3	-14.5	-16.6	-20.6	-14.6	-17	-19.9
10^{th} Percentile % bias q	-9.7	-11.5	-13.9	-10.0	-11.4	-13.7	-8.2	-11.2	-13.9	-7.2	-9.95	-13.9
25^{th} Percentile % bias q	-5.3	-6.45	-7.7	-5.5	-6.2	-7.5	-4.5	-6.2	-7.7	-3.7	-5.45	-7.7
75^{th} Percentile % bias q	5.0	6.1	7.8	5.0	6.2	8.0	4.3	6.2	7.7	4.0	5.7	7.9
90^{th} Percentile % bias q	10.0	12.1	15.8	9.9	12.2	15.9	8.6	12.3	15.6	7.7	10.9	15.8
97.5 Percentile % bias q	16.2	19.4	26.1	15.9	19.6	25.1	16.1	19.3	25.4	15.8	19	25.8
CV of q	0.08	0.09	0.12	0.08	0.09	0.12	0.08	0.09	0.12	0.08	0.09	0.12

Table 6. Biases in estimates of natural mortality and catchability and coefficients of variation for skipjack tuna.

	Baitboat (45%)			*Even (34%)*			*Concern (17%)*			*Uncertainty in q (50%)*		
	High	*Med*	*Low*	*High*	*Med*	*Low*	*High*	*Med*	*Low*	*High*	*Med*	*Low*
Median % bias M	0.01	0.04	0.12	-0.03	0.03	0.06	0.03	-0.09	-0.35	-0.004	0.04	0.04
2.5 Percentile % bias M	-8.6	-10.7	-13.3	-9.2	-11.5	-15	-11.6	-15.2	-21	-8.3	-10	-12.9
10^{th} Percentile % bias M	-5.5	-6.8	-8.9	-5.9	-7.5	-9.7	-7.0	-9.9	-13.8	-4.2	-6.0	-8.4
25^{th} Percentile % bias M	-2.9	-3.6	-4.7	-3.0	-4.0	-5.2	-3.7	-5.2	-7.4	-2.2	-3.1	-4.4
75^{th} Percentile % bias M	3.0	3.6	4. 6	3.2	4.1	5.3	3.8	5.2	7.1	2.3	3.2	4.5
90^{th} Percentile % bias M	5.7	6.9	8.9	6.1	7.7	10.4	7.3	10.4	14.1	4.3	6.1	8.7
97.5 Percentile % bias M	8.6	10.7	14.2	9.2	11.7	15.7	12	16.1	21.8	8.5	10.6	13.4
CV of M	0.04	0.05	0.07	0.05	0.06	0.08	0.06	0.08	0.11	0.04	0.05	0.07
Median % bias q	-0.27	0.03	-0.003	-0.02	-0.43	-0.22	-0.04	0.10	0.29	0.06	0.06	-0.25
2.5 Percentile % bias q	-11.2	-12.5	-14.9	-12	-13.4	-16.4	-13.6	-16.3	-21	-11.2	-12.2	-14.6
10^{th} Percentile % bias q	-7.5	-8.4	-10.0	-7.8	-9.0	-11.1	-8.1	-11.0	-14.3	-5.0	-7.0	-9.9
25^{th} Percentile % bias q	-4.0	-4.6	-5.4	-4.3	-5.2	-6.2	-4.4	-6.1	-7.9	-2.7	-3.8	-5.6
75^{th} Percentile % bias q	3.9	4.6	5.7	4.1	4.8	6.1	4.	6.3	8.8	2.7	3.9	5.3
90^{th} Percentile % bias q	7.7	9.0	11.2	7.8	9.5	12.3	8.7	12.5	17.3	5.2	7.7	10.7
97.5 Percentile % bias q	11.8	14.3	17.7	12.4	15.5	20.4	15.4	20.3	27.7	11.9	14	17.1
CV of q	0.06	0.07	0.08	0.06	0.07	0.09	0.07	0.09	0.12	0.06	0.07	0.08

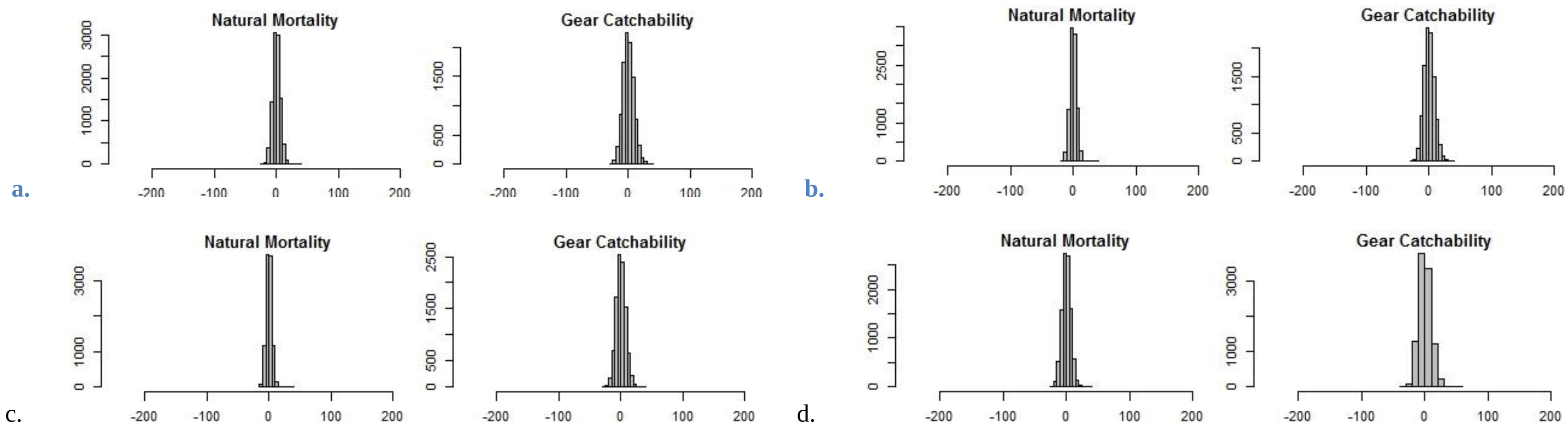

Figure 1. Percent bias of parameter estimates for the high tagging effort for yellowfin tuna for each scenario: a. batiboat; b. even; c. concern; d. q uncertainty.

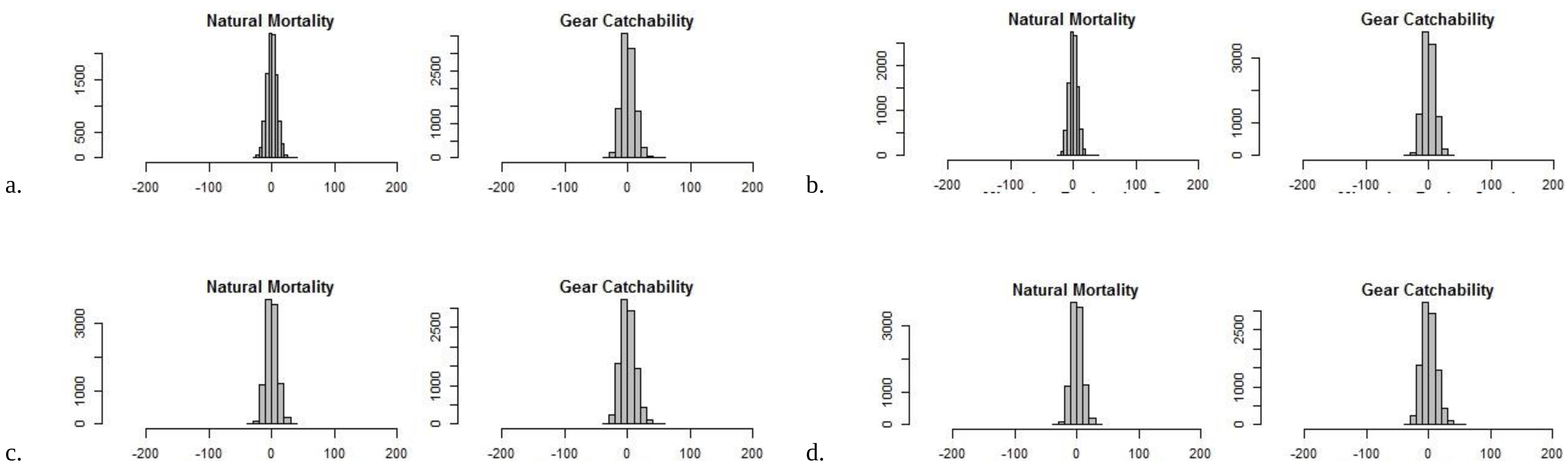

Figure 2. Percent bias of parameter estimates for the medium tagging effort for yellowfin tuna for each scenario: a. batiboat; b. even; c. concern; d. q uncertainty.

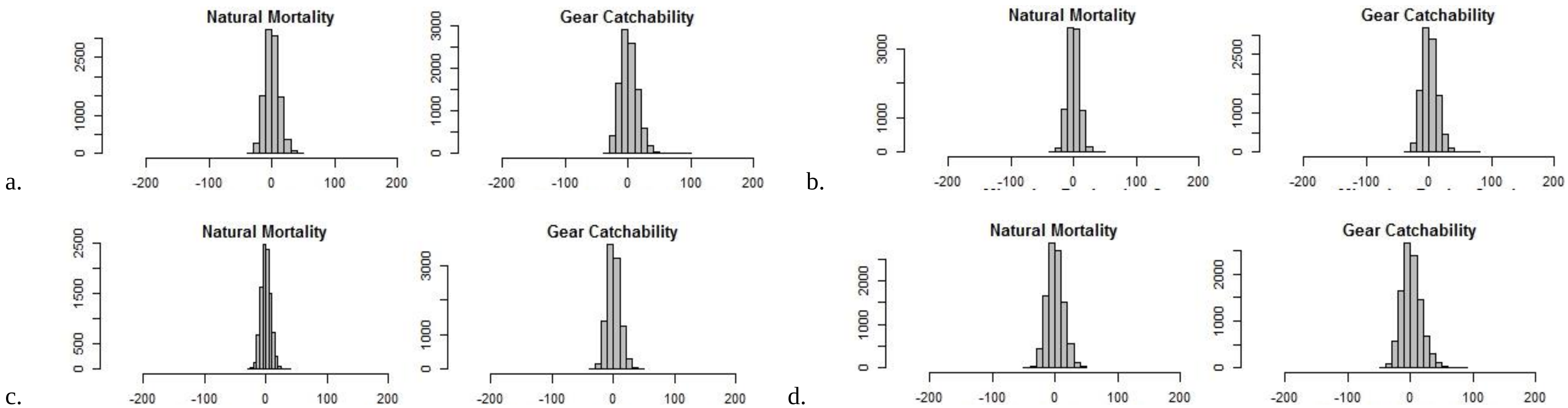

Figure 3. Percent bias of parameter estimates for the low tagging effort for yellowfin tuna for each scenario: a. batiboat; b. even; c. concern; d. q uncertainty.

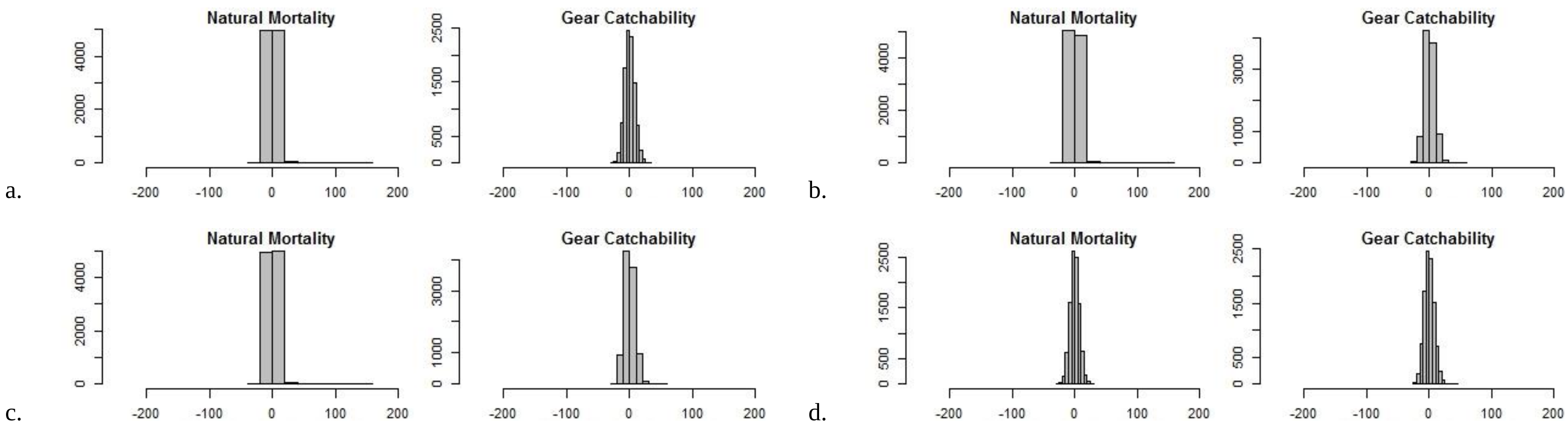

Figure 4. Percent bias of parameter estimates for the high tagging effort for bigeye tuna for each scenario: a. batiboat; b. even; c. concern; d. q uncertainty.

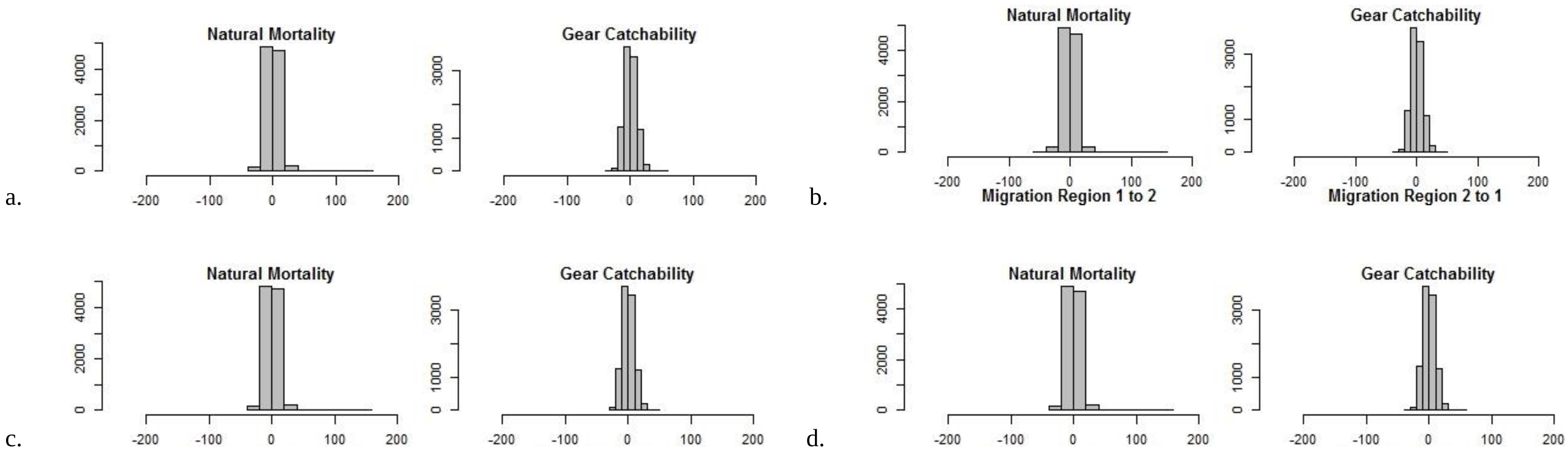

Figure 5. Percent bias of parameter estimates for the medium tagging effort for bigeye tuna for each scenario: a. baitboat; b. even; c. concern; d. q uncertainty

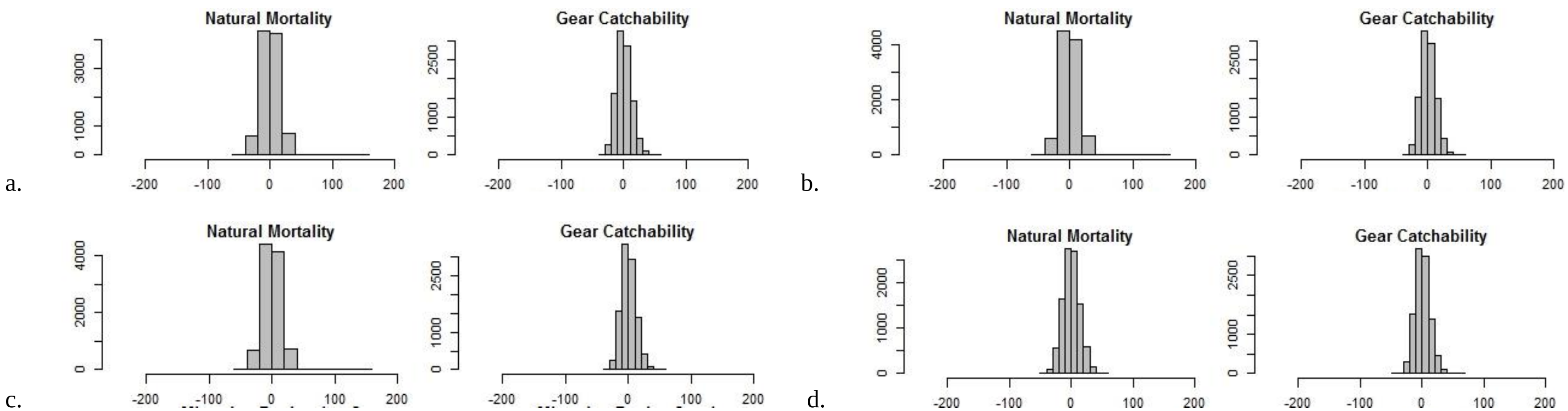

Figure 6. Percent bias of parameter estimates for the low tagging effort for bigeye tuna for each scenario: a. batiboat; b. even; c. concern; d. q uncertainty.

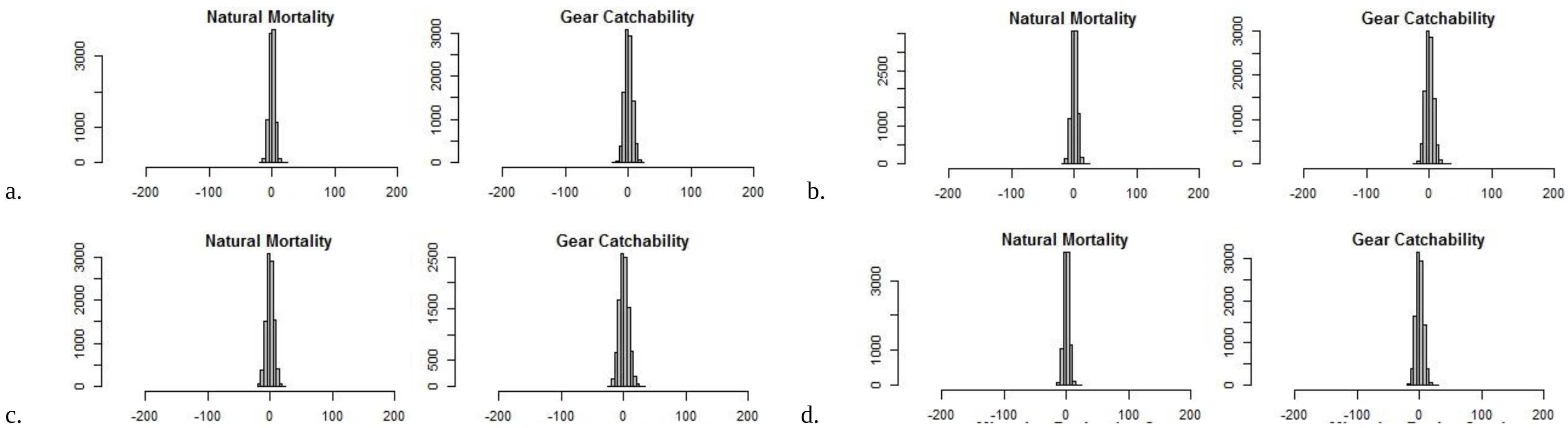

Figure 7. Percent bias of parameter estimates for the high tagging effort for skipjack tuna for each scenario: a. batiboat; b. even; c. concern; d. q uncertainty.

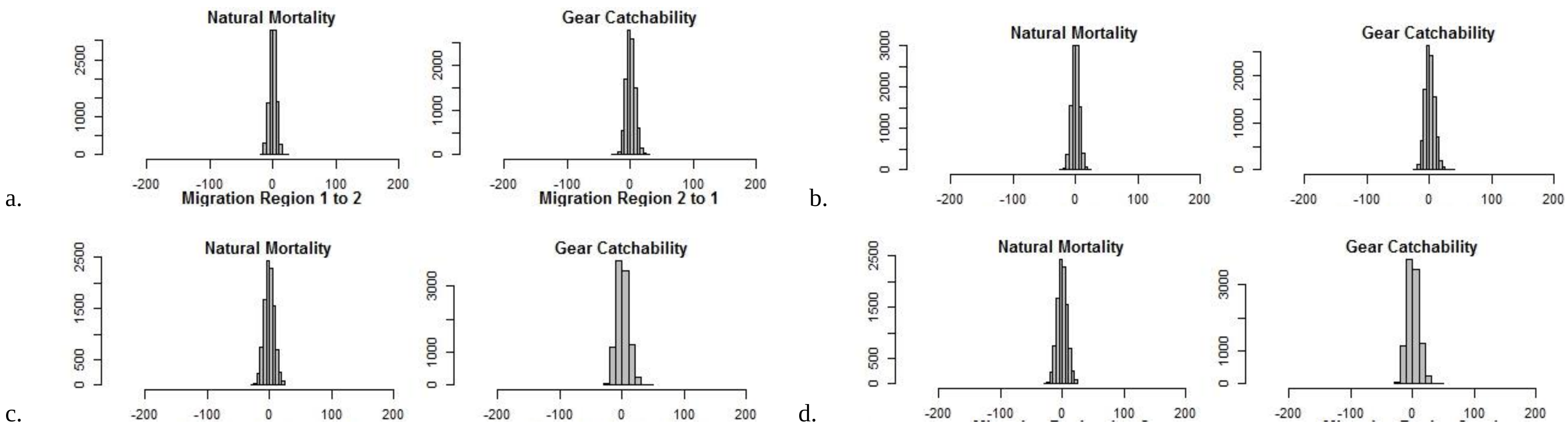

Figure 8. Percent bias of parameter estimates for the medium tagging effort for skipjack tuna for each scenario: a. batiboat; b. even; c. concern; d. q uncertainty.

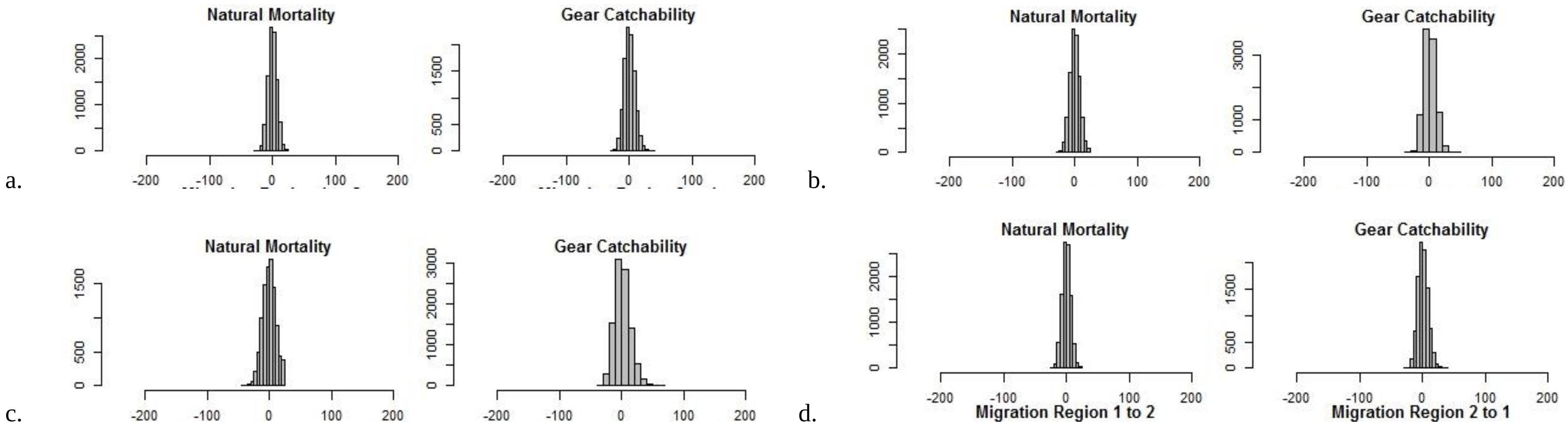

Figure 9. Percent bias of parameter estimates for the low tagging effort for skipjack tuna for each scenario: a. batiboat; b. even; c. concern; d. q uncertainty.

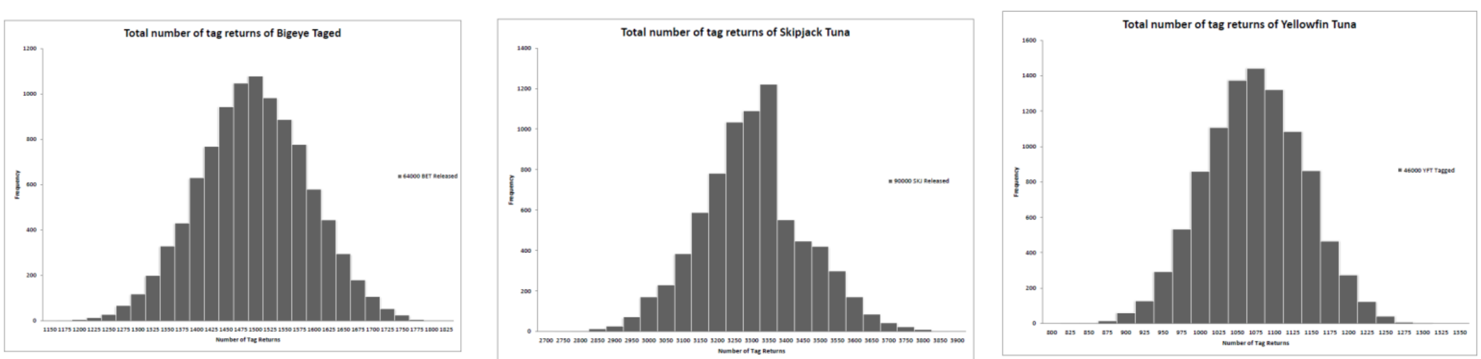

Figure 10. Simulated numbers of recaptured bigeye tuna, skipjack and yellowfin tuna for the “baitboat” scenario and high tagging effort.

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THE ATLANTIC OCEAN TUNA TAGGING PROGRAM (AOTTP) TASK FORCE WORK PLAN

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SUMMARY

The objective of this document is to establish the basis for the development of the proposal for a global Tagging Program on tropical tunas in the Atlantic. The document presents background information on tagging activities conducted in the past within ICCAT as well as information on similar experience carried out in other oceans. The document also includes a definition of the main objectives of the program and the main components to be developed in the proposal.

ÉSUMÉ

L'objectif du présent document est d'établir les bases de la formulation d'une proposition portant sur un programme de marquage mondial des thonidés tropicaux dans l'Atlantique. Le document présente des informations de référence sur les activités de marquage réalisées par le passé au sein de l'ICCAT ainsi que des informations sur des expériences similaires réalisées dans d'autres océans. Il inclut également une définition des principaux objectifs du programme et des principaux éléments à élaborer dans la proposition.

RESUMEN

El objetivo de este documento es establecer la base para el desarrollo de la propuesta para un programa mundial de marcado de túnidos tropicales en el Atlántico. En el documento se presenta información de referencia sobre actividades de marcado realizadas en el pasado en ICCAT, así como información sobre experiencias similares en otros océanos. El documento incluye también una definición de los principales objetivos del programa y de los principales elementos que se tienen que elaborar en la propuesta.

1 Context

1.1 Tropical tuna catches in the Atlantic

Since the beginning of the fishery in 1950 and until the early-90s, tropical tuna catches in the Atlantic ocean have rapidly increased to reach a peak in 1990, 1991 and 1994 respectively for yellowfin, skipjack and bigeye tuna (**Figure 1**). After these years, catches for all threes species decreased steadily as the stocks reached a level of full exploitation, management measures were introduced and a tuna fishery started in the Indian Ocean (Miyake et al., 2010). During recent years, catch of tropical tunas, and in particular of skipjack have shown an increasing trend, mainly due to the large catches of the purse seine EU-Spain fleet and the development of a purse seine fleet in Ghana.

Three main gears are catching the majority of the tropical tuna in the Atlantic ocean, baitboat, longline and purse seine, the latest being by far the most important as purse seine catches represent more than 50% of the total catch of tropical tuna in the Atlantic ocean since 1975 (**Figure 2**).

The large catches of tropical tunas in the Atlantic ocean, over 300 000 tons since the early 80s, are essential to the economies of some coastal countries of the Atlantic and of some distant water fishing nations and highlight the need for management to ensure the sustainable exploitation of the resources. With slightly less than 400 000 tons in 2011, the Atlantic tropical tuna fishery represents around 10% of the global tropical tuna catches, while the Pacific and the Indian oceans contribute respectively to 78% and 22%.

[1] SCRS Tropical Tuna Species Group, 25-27 September 2009, Madrid

1.2 Management of TT stocks in the Atlantic ocean

The International Commission for the Conservation of Atlantic Tunas (ICCAT) was created in 1966 and is the Regional Fisheries Management Organization (RFMO) responsible for the management of tropical tuna stock, among others, in the Atlantic Ocean and adjacent seas. The ICCAT currently counts 48 Contracting Parties.

As part of its management process, the ICCAT is undertaking regular stock assessments for the three tropical tuna species. The latest assessments were realized for yellowfin in 2011 (data up to 2010), for bigeye in 2010 data up to 2009) and for skipjack in 2008 (data up to 2006), and the stock status were as follow (ICCAT, 2012):

- yellowfin: stock is overfished
- bigeye: not overfished and overfishing is not occurring
- Eastern skipjack: not overfished and overfishing is not occurring.
- Western skipjack: not overfished and overfishing is not occurring

However, it is noted that uncertainty remains high for all three assessments, as some key-parameters of population dynamic, life history and biology, which would improve the results and robustness of the assessments are still missing or largely unknown (ICCAT, 2012, 2010). These include:

- stock structure
- natural mortality
- growth
- movements, *etc.*

These parameters are fishery independent and, as tropical tuna are pelagic species, the best way to estimate them is through the information obtain by tag-recapture experiments. In fact, tagging provide relevant data for stock assessment as well as for the evaluation of fisheries management measures, *e.g.* time-area closure, and has been conducted for many years in tuna fisheries.

1.3 History of tagging programmes under the ICCAT framework

Several tagging experiments have been conducted in the Atlantic Ocean since the mid-1950s, some of them having being implemented under the ICCAT framework. Tagging started in the Atlantic in 1956 with the first experiments being conducted by the USA and South Africa and since then, tropical tunas have been tagged almost every year in the region (Bard, 1989; ICCAT, 1991; Bard and Bannerman, 2002). These tagging experiments were a combination of dedicated projects, with dedicated tagging cruise, and opportunistic tagging activities implemented during commercial operation. Most of the experiments were implemented nationally and ran for short period of time. However, the number of releases and recoveries for each campaign was quite limited (**Figure 3**) and today the information has limited use in the stock assessment. In 2011, the ICCAT developed a central tagging database system (Palma and Kebe, 2009) to store the data that had been collected since the mid-50s. Today, this database contains information on 72012 releases of tagged tropical tuna and 11285 recoveries (**Table 1**).

The central tagging database of ICCAT, however, does not contain information on all tagging experiments conducted in the Atlantic so far, in particular before 1988. In fact, inventories of the annual number of releases in the Atlantic (Bard, 1989; ICCAT, 1991; Bard and Bannerman, 2002) until 1988 include a much large number of releases than currently included in the ICCAT tagging database

In fact, more tagging was undertaken however the data is not yet included in the ICCAT Secretariat, mainly because the recording and storing system were different. Recently, the USA and the Secretariat have worked towards improving tagging data exchanges (ICCAT, 2009).

The lack of a centralized tagging database containing all the relevant tagging data on tropical tuna, but also on other species under the management mandate of ICCAT, does not help to integrate tagging data to stock assessment.

1.3.1 International Skipjack Year Program - ISYP (1978-1982)

Following the large development of a purse seine fleet in the Atlantic Ocean, the ICCAT SCRS recommended in 1976 that a research program was developed to obtain necessary information for a skipjack stock assessment (ICCAT, 1986). This program, the International Skipjack Year Program (ISYP), was a four years program that started in 1978. Among other activities, the ISYP included tagging experiments to which 12 countries participated. In total 35 000 skipjack were tagged during the project (ICCAT, 1986), with more than 85% released in the eastern Atlantic ocean.

1.3.2 Yellowfin Year Program – YYP (1986-1987)

End of 1983 and during 1984, very low yellowfin catch rates were observed in the Atlantic which resulted in the departure of several purse seiners to the growing Indian Ocean fishery. The SCRS recommended to carry out extensive research in order to explain these low catches rates and the consequences on the stock of the reduction of effort that followed (ICCAT, 1991). The YYP included tagging activities in the Eastern Atlantic ocean, however the results were mitigated with only 3 026 fished tagged and released, and 138 recoveries reported to the Secretariat.

1.3.3 Bigeye Year Program – BETYP (1999-2003)

From 1999 to 2003, the ICCAT implemented a dedicated research program on bigeye tuna in order to clarify the stock structure of bigeye tuna and to study the impact of the fisheries on the stocks (Fisch, 2005). The BETYP included dedicated conventional tagging activities in Azores, Madeira, Canary Islands, Senegal, Ghana and São Tome and Principe during which 22 674 tunas were tagged (24.3% BET, 23.1% YFT and 52.6% SKJ). A total of 3 786 tagged fish were recaptured and reported with recovery rates being respectively for bigeye, yellowfin and skipjack of 31.3%, 7.74% and 13.88%. In addition, 42 electronic tags (23 pop-up and 19 archival) were deployed on bigeye tuna.

1.4 Other tagging activities in the Atlantic Ocean

Several other tagging initiatives have been implemented in the Atlantic ocean (ICCAT, 2008).

1.4.1Matte Associées aux Canneurs - MAC (1996-2000)

The Institut de Recherche pour le Développement had developed a four years project in to study the associated school fishing technique in the baitboat fishery based in Dakar, Senegal. Part of this project included tuna tagging during commercial operations onboard baitboat. The tagging effort was reinforce in 1999-2000 with funding from the BETYP project. In total 10 402 tuna were tagged during the MAC project (3 012 BET, 6 715 SKJ and 1 597 YFT), of which 3 181 were recovered and reported (Hallier et al., 2001; Hallier, 2005).

1.4.2 Southeast Fisheries Science Center's Cooperative Tagging Program (CTC)

The Cooperative Tagging Program (CTC) of the Southeast Fisheries Science Center's started in 1954 in the USA and has now tagged more than 200 000 tuna and billfish. The CTC is a program based on voluntary program from anglers and fishing operators.

1.4.3 The Billfish Foundation Tagging Program (TBF)

The Billfish Foundation (TBF) has developed a tagging program targeting billfish since 1990. The TBF is cooperating with the CTC.

1.4.4 National Programs

Some more tagging activities are also implemented at a national level by different institutions in Atlantic coastal countries. These projects are undertaken with dedicated experiments as well as with opportunistic tagging during commercial operations.

1.5 Other example of large-scale tuna tagging programme

Successful large-scale tuna tagging programs have been undertaken in the Pacific and in the Indian Ocean releasing hundreds of thousand of tagged tuna. All of these programs were very successful and have gathered a large amount of data which are now used routinely for stock assessments.

1.5.1Pacific Ocean

In the Pacific ocean, the first tagging project, the skipjack Survey and Assessment Programme (SSAP) was conducted from 1977 to 1981. 150 000 tuna were successfully tagged and release (95%) skipjack with a recapture rate of around 4%. As the purse seine fishery expanded quickly during the 80s, a second large-scale tagging program was conducted in the Pacific, the Regional Tuna Tagging Project (RTTP) which took place between 1989 and 1992. 146550 (67% SKJ, 27% YFT and 6% BET) tuna were tagged and released over a large area of the Pacific Ocean, and recovery rate was around 12.5%, with over 18 000 recoveries reported. In 2006, a new program was conducted under the WCPFC framework, the Pacific Tuna Tagging Programme (PTTP), which lasted 20 months and was prolonged by a second phase lasting 11 months. In 2011, the Papua New Guinea Tagging Project (PNG-TP) started and lasted 3 years, and the last cruise ended in March 2013.

In total, since 2006, almost 400 000 tunas have been tagged and released in the Pacific Ocean, with a recovery rate to date of over 16%.

1.5.2 Indian Ocean

For more than 15 years, scientists have been calling for a large-scale tuna tagging project to be implemented in the Indian Ocean. In 2002, the Indian Ocean Tuna Tagging Programme (IOTTP) started under the supervision of the Indian Ocean Tuna Commission (IOTC). The programme was composed of a large-scale component, the Regional Tuna Tagging Project – Indian Ocean (RTTP-IO), and a suite of complementary small-scale projects, *i.e.* in India, Indonesia, Maldives, Mayotte, *etc.* In total, 201 425 tuna were tagged and released (RTTP-IO: 168 163 - 85%, SS: 33 262) in the Indian Ocean (**Figure 4**), and over 32 300 were recovered to date.

Releases took place mainly in the western Indian Ocean, where the main phase of the programme, the RTTP-IO, was based, however the recoveries were well spread with fish being recovered in the eastern Indian Ocean and even in the Atlantic ocean (**Figure 6)**.

The IOTTP generated an extensive datasets, and tagging data have been integrated in yellowfin stock assessment since 2008, in bigeye stock assessment since 2011 and in skipjack stock assessment since 2012.

2 Definition of AOTTP objectives

In order to fulfil its management mandate, the ICCAT needs reliable stock assessments. However, today, the uncertainty of these analyses remains high as some fishery independent key-parameters are still missing. A series of tagging projects have been implemented in the past, but most of them were small operations, *i.e.* not ocean scale, with limited results. Moreover, the tagging information available today for tropical tuna in the Atlantic is not centralized. As a result, most of the tagging data for tropical tuna are not included in the stock assessment or is not very informative.

In order to better reply to the Commission's requests and improve the stock assessments, the SCRS has been recommending for several years that a large-scale programme is implemented under the ICCAT framework in order to gather the necessary data to estimate the lacking information for future stock assessments (ICCAT, 2012, 2011, 2010). Such an experiment would be a project at the scale of the Atlantic Ocean, targeting the release and recovery of large number of fish from the three main tropical tuna species and coordinated under the ICCAT framework. ICCAT would also be the repository of the data gathered, which would be made available to undertake the necessary analyses. Ultimately the tagging data gathered would be integrated in the stock assessments in order to reduce their uncertainty.

The objectives of such a programme have to be well defined and precise in order to adapt the strategy and resources to fulfil them.

A Task Force, composed of the Chair of the SCRS, the Tropical Tuna coordinator and the Tropical Tunas rapporteurs and a consultant has been created to discuss and prepare the AOTTP. It is open to any interested scientist. The Task Force will be working on the definition of clear objectives, on the development of a detailed project proposal, on Terms of Reference for a Feasibility study and on the different funding opportunities for the AOTTP.

2.1 Overall objective

The overall objective of the Atlantic Ocean Tuna Tagging Programme (AOTTP) is ***to improve the sustainability of tropical tuna resources by providing the best science available to ICCAT***.

2.2 Specific objectives

In 2010, the SCRS defined some specific objectives for the project (ICCAT, 2010), which were later revised during the Inter-sessional meeting of the tropical tuna species group (ICCAT, 2013a):

1. Estimation of recent exploitation rates for tropical tunas
2. Integration of tagging information to spatialized stock assessment models and analyses of the effectiveness of management measures (e.g. time are closures, FAO management, *etc.*).

2.3Expected outputs

The specific outputs for the project:

a) Confirmation of the current stock structure for the three species of tropical tuna, and analysis of their movements across the Atlantic ocean,

b) Estimation of recent fishing mortality rates independently from CPUE,

c) Estimation of the level of interactions between surface and longline fisheries,

d) Estimation of age-area-sex specific growth rates,

e) Estimation age-specific natural mortality rates,

f) Estimation of tag-shedding and tag reporting rates by gear and flag.

g) Study the effect of *i)* drifting FADs on the movement patterns and biology of skipjack (at all stages) and of juveniles bigeye and yellowfin, *ii)* the associated school fishing technique in some baitboat fisheries as well as *iii)* the residence time of tunas around seamounts.

h) Study the link between environmental conditions and distributions and abundance of tropical tunas.

Furthermore, in 2013 the Tropical Tunas species group noted that the AOTTP would also be a good opportunity to contribute to the stock assessment of Atlantic bonito and Atlantic blackfin tuna (ICCAT, 2013a). Blackfin (*Thunnus atlanticus*) is an oceanic species occurring in the tropical western Atlantic and often mixing with skipjack and there could be tagging opportunities. However, Atlantic bonito (*Sarda sarda*) is a neritic tuna living along the tropical coasts of the Indian Ocean. Tagging such of neritic tuna might be difficult in the context of the AOTTP and should be considered with caution.

2.4 Development of a project proposal

Once the objectives are defined and agreed upon, the Task Force will work towards the development of a project outline. This will be use to define the approach, or the different possible approaches, for the AOTTP which could give a first indication f the budget required.

2.4.1 Tagging strategy

Unlike in the Indian Ocean, there are several baitboat fleets in the Atlantic and the knowledge of these fleets is a great opportunity to multiply simultaneous/successive releases operations in a wide area of the Atlantic. In 2011, 9 fleets have been reporting baitboat catches to the ICCAT for a total of 83 419 tons. Four main fleets, *i.e.* Brazil, EU-Spain, Ghana and EU-Portugal are catching 88% of the total. In addition the fishing grounds of those fleet are located in the different part of the Atlantic. Baitboat vessels could be chartered from these fleets for the purpose of the program.

The Program should be conducted over a period of around 5 years, including tagging activities over a period of at least 2.5 years. Recoveries activities should extend at least 2 years after the end of the tagging activities. This would ensure that:

- cohorts are tagged during several consecutive years
- a significant number of tags are releases in a large area and on different size classes
- the risk of tagging only during a period with abnormal climatic conditions that could influence the availability of tuna is avoided.
- estimate age specific parameters (*e.g.* growth, M, *etc.*)

All size classes are not easily available to baitboat which catches in general small tuna, this is particularly true for yellowfin and bigeye. This should be kept in mind when designing the project and other platforms, or specific areas, should be consider in order to be able to tag larger fish of this two species

2.4.2 Structure of the AOTTP

For the Indian Ocean program, as well as for some programs in the Pacific programs, the tagging experiments are a combination of a large-scale project and some complementary smaller scale projects. These projects have in general particular objectives or particular area to be covered. In the Indian Ocean for example, the large-scale component, the RTTP-IO, was operated in the western part of the basin, from Madagascar to Oman. Small-scale operations were developed in order to tag and release fish in the central Indian Ocean, *i.e.* Maldives and Lakshadweep (India) and in the eastern Indian Ocean, *i.e.* Indonesia and Andaman Islands (India). In addition, one small-scale project was undertaken in Mayotte (France) in order to tag and release with handlines medium and large-scale yellowfin which are less catchable by baitboats.

However, small-scale operations needs to be carefully planned and are not always successful. During a large-scale project that last several years, the tagging teams and the vessel crew are well train and the quality of their tagging is high. During small-scale operation which are limited in time, the crew of the vessel and the local tagging team shave to be trained, the turnover is high and this can impact directly the results of the experiment by lowering the quality of the tagging, *i.e.* increasing shedding and post-tagging mortality.

Given the different objectives of the AOTTP, the area to be covered and the availability of baitboat vessels in the region, the Task Force should define the best structure for the AOTTP.

2.4.3 Areas to be covered

Defining the targeted area to tag and release fish is not an easy task, however, a much a possible tag should be releases in the largest area possible. This would allow to:

- estimate movements of tropical tuna in the Atlantic
- estimate interactions between surface and longline fisheries
- confirm the stock structure for 3 species
- estimate area specific parameters (*e.g.* growth, M, *etc.*)

Catches of tropical tunas in the Atlantic are well spread along the coast of Africa and along the equator, in the Gulf of Guinea, along the north and south American coasts, and in the Caribbean, however with some specificities depending on the species (**Figure 8).** Moreover, the logistic involved with the chartering of a fishing vessel, the bait availability, the rotation of crew and tagging teams bring heavy constraints that cannot be forgotten during the planning.

To take into account these different aspects and better plan and target the areas where the releases should be done in priority to reach the objectives of the of the program, computer simulations could be undertaken. They should include the different logistical aspects together with the bait and tuna availability.

2.4.4 Type of tags to be used

In order to tag fish, and in particular tuna, several types of tags can be used (**Figure 9**), and each of them can be used to reached different objectives.

- The most commonly used tag is the conventional “spaghetti” tags. These tags consist of a plastic streamer with a unique identification number and an address to return it and is inserted at the base of the second dorsal fin, through the pterygiophores.

- Archival tag and pop-up tags are electronic tags that record every few second a number of data such as the depth, the temperature (internal – external) and the light intensity. Pop-up tags have the advantages that the data is transmitted through satellite, and therefore they do not need to be recovered.
- Chemical tagging is done with oxytetracycline or strontium chloride, products that will leave a deposit in the otolith of the fish on the day of tagging. These are used for growth studies.
- The new generation RFID tags have not yet been used for tagging tropical tunas on a large-scale. This type of tags offers the possibility of being automatically detected with a reader.

The different tag types to be used for the AOTTP would depend on the objectives of the project, but in general most tagging programme included the releases of a very large-majority of conventional tags (more than 100 000) and a small proportion of electronic tag (less than 1000) due to their expensive prices.

2.5 Publicity and recovery campaign

Tagging is only the first step of such a large-scale programme, however, the real data comes after, from the recoveries of these tagged tuna. The development of publicity and recovery campaign is not as impressive as the deployment of fishing vessel going at sea to tag fish, and is to often underestimated. This was the case in the Indian Ocean, where the feasibility study, and therefore the final budget allocated, did not put enough emphasis on the important phase of the project ; the RTTP-IO was lacking funding but most importantly it was lacking staff with only one person dedicated to publicity and tag recovery campaign.

The publicity and tag recovery campaign should be planned well in advance of the start of the tagging activities. Even if there was no large-scale project in the Atlantic so far, tagging activities have been undertaken regularly since the mid-50s in the Atlantic. Fishermen, stevedores and other stakeholders might already be acquainted with the recovery of tagged tunas, and ICCAT has already contacts and counterparts in the different coastal countries. This would need to be reviewed and expanded to be able to involve the different participating countries, sensitize the different stakeholders of the project and work with them in defining adapted recovery strategies.

Recovery scheme should be developed in all costal countries of the Atlantic, as well as in Distant Water Fishing Nations catching or processing fish from the Atlantic. Rewards will be offered to the finder of the tags to motivate them to return the tags with the proper information to the program. The reward scheme should be *i)* adapted to the different countries (*e.g.* value of the reward, type of in kind reward), *ii)* should be fast process in order to give the reward immediate to the finder.

Additionally, recovery platforms should be prioritize in order to better allocate the resources of the program, and priority should be given to the platforms for which reporting rate can be estimated.

2. 6Auxiliary information needed to analyse tagging data

During a tagging experiment, factors can bias the number of tagged fish that are being recaptured, *i.e.* the shedding of the tags and the reporting rate of the recaptured tuna.

2.6.1 Tag shedding

In order to estimate tag shedding, *i.e.* the proportion of the tags that will fall from the fish before its recapture, some double tagging should be realized. During double tagging, two tags are placed independently on the fish, on each side of its second dorsal. Double tagging should be undertaken regularly during the program, by all taggers in all conditions, and should reach between 15% and 20% of the total number of releases. At recovery, the number of double tagged fish recovered with only one tag and with the two tags will be analyzed to estimate the tag shedding rate.

2.6.2 Tag reporting

Unfortunately, not all the recovered tagged fish are reported to the program. This can be due to several reason: *i.* the tag finder is not aware of the recovery procedure, *ii.* The tag finder has lost the tag before reporting it, *iii.* the reward scheme is not attractive enough for the tag finder to report it, *etc.*

It is therefore necessary to be able to estimate the proportion of the recaptured tagged fish that are not reported as such to the program. Tag reporting rates can be estimated through *i)* a tag seeding experiment, consisting of placing tagged fish directly inside the catch a fishing vessel and monitoring their return, or *ii)* by comparing the return rates from the fishery with those from a control group, *e.g*. high-value rewards, observed fishing trips, surveyed anglers, *etc*. (Hampton, 1997; Cadigan and Brattey, 2003; Dicken et al., 2006; Polacheck et al., 2006).

Tag seeding was conducted in the Pacific and in the Indian Ocean in order to test the reporting rate of stevedores for the purse seine fishery. In fact, this fishery is catching tuna in large quantities, and in the Indian Ocean, from this fleet, around 80% of the recoveries where reported by stevedores (recoveries at unloading/transhippping), with the remaining 20% being reported by fishers (recoveries during fishing).

In Seychelles during the IOTTP, around 3000 tags were seeded onboard the European purse seine fleet between 2004 and 2009. The results showed a rapid increase of the reporting rates for all three species after the start of the tagging activities from the RTTP-IO. Tag reporting rates increased from around 50% to over 95% after two quarters of tagging (22 000 releases).

2.7 Cooperation

For such a program to be successful, in addition to funding, tagging vessels, equipment and personnel, it needs the full cooperation all coastal countries and other members of ICCAT. This is very important in order to secure access to EEZ, for both continental (for bait) and deep waters (tunas), to ports and also to ensure the participation of some of their staff to the program, in particular for the recovery process.

This should be secure in advance at the level in order to avoid delays when the activities will start, in particular as access can be quite long to obtain in some countries.

2.8 Funding opportunities

Large-scale tagging projects are the best tool to gather necessary fishery independent key-parameters and have been implemented in the past in the Pacific and Indian oceans with great success. However, such projects need important funding and resources and a lot of planning.

In the Indian Ocean, all the funds for the large-scale program came from the EU DG-Development (14 millions €), however they usually do not fund 100%. Additional funding was provided by Japan and the DG-Mare for the small-scale projects. The situation was very different in the Pacific, where they had for their different programs a wide range of contributors, CPCs of WCPFC and IGOs (New Zealand, EU, Australia, GEF, Korea, France, China, PNG).

In the Atlantic, some important players in the tropical tuna fisheries are developed countries which are potential contributors (EU, USA, Japan, Canada, Korea, China, France, *etc.*), and they could be contacted in order to seek their support, monetary or in kind, for the AOTTP. A multi-donors program allows more flexibility in the way the activities are run. In fact, some donors have specific rules on how the money is spent (*e.g.* the EU), and have different sources of funding will eliminate some of these constraints. IGOs, NGOs and private companies could also provide support to the program.

3 Conclusion

A large-scale tagging program is needed in the Atlantic ocean, and the AOTTP would be an ambitious program to gather the information needed to improve stock assessment in order to ensure the sustainable management of the tropical tuna resources. Such a program always include a large amount of risk, and therefore the AOTTP should be carefully designed and planned in order to meet its different objectives.

It is proposed that the Task Force will work towards the development of a comprehensive proposal for the AOTTP, including:

- detailed objectives
- tagging strategy
- indicative budget
- contact with potential donors and contributors

This would allow writing specific terms of reference for a comprehensive feasibility study to be undertaken for the planning of the activities of the AOTTP.

The AOTTP should follow the implementation of the five other successful large-scale projects that took place in the Pacific and Indian Oceans, as these programs have many similarities with what is expected from the AOTTP, in terms of objectives and logistical requirements.

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Table 1. Number of releases and recoveries of tagged fish in the ICCAT database.

	Releases	*Recoveries*
BET	11198	2877
SKJ	42635	6849
YFT	18179	1559

Table 2. Comparison of the number of releases of tropical tuna per species between inventories in the literature and the ICCAT database from 1956 to 1988.

	Inventories	*ICCAT db*
YFT	21 555	4 526
SKJ	36 654	20 052
BET	7 183	2 236
TOTAL	**65 392**	**26 814**

Table 3. Number of tagged tuna released in the Pacific ocean from 2006 to 2013 (source: www.spc.int).

Species	*Releases*	*Recoveries*	*%*
Albacore	2877	19	0.66
Bigeye	40770	10288	25.23
Skipjack	246717	37914	15.37
Yellowfin	106085	15889	14.98
Total	**396449**	**64110**	**16.17**

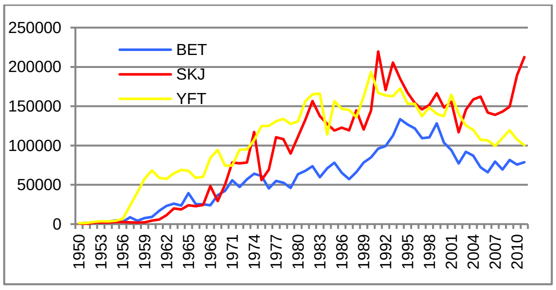


Figure 1. Nominal catches of tropical tunas in the Atlantic ocean from 1950 to 2011 (source: ICCAT)

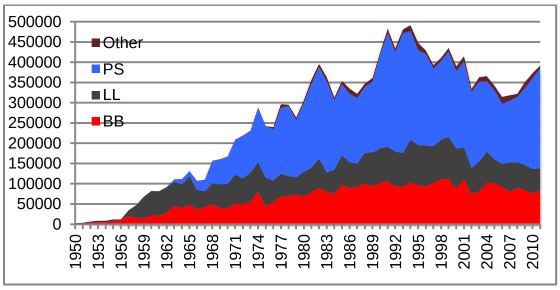


Figure 2. Nominal catch of tropical tunas in the Atlantic ocean by gear from 1950 to 2011. (source: ICCAT)

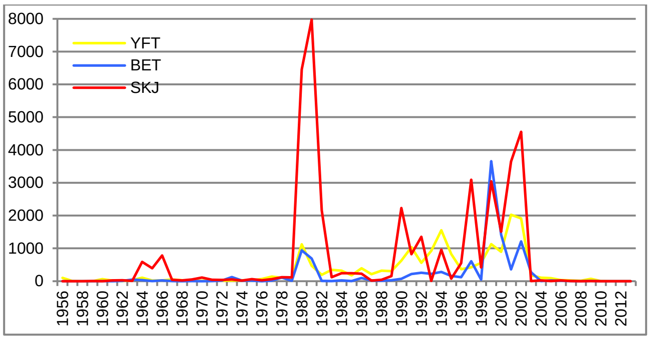


Figure 3. Releases of tagged fish per species recorded in the ICCAT database

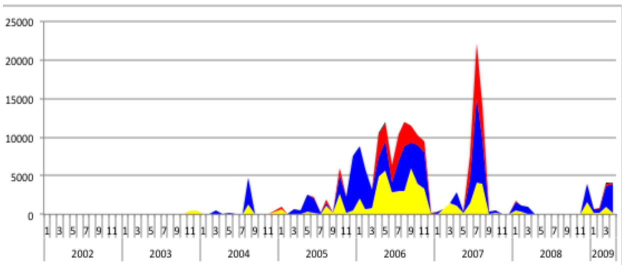


Figure 4. Monthly releases of tagged tuna per species in the Indian Ocean between 2002 and 2009.

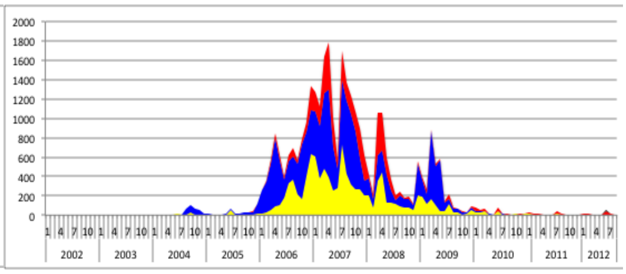


Figure 5. Number of recoveries of tagged tuna per species in the Indian Ocean between 2002 and 2009.

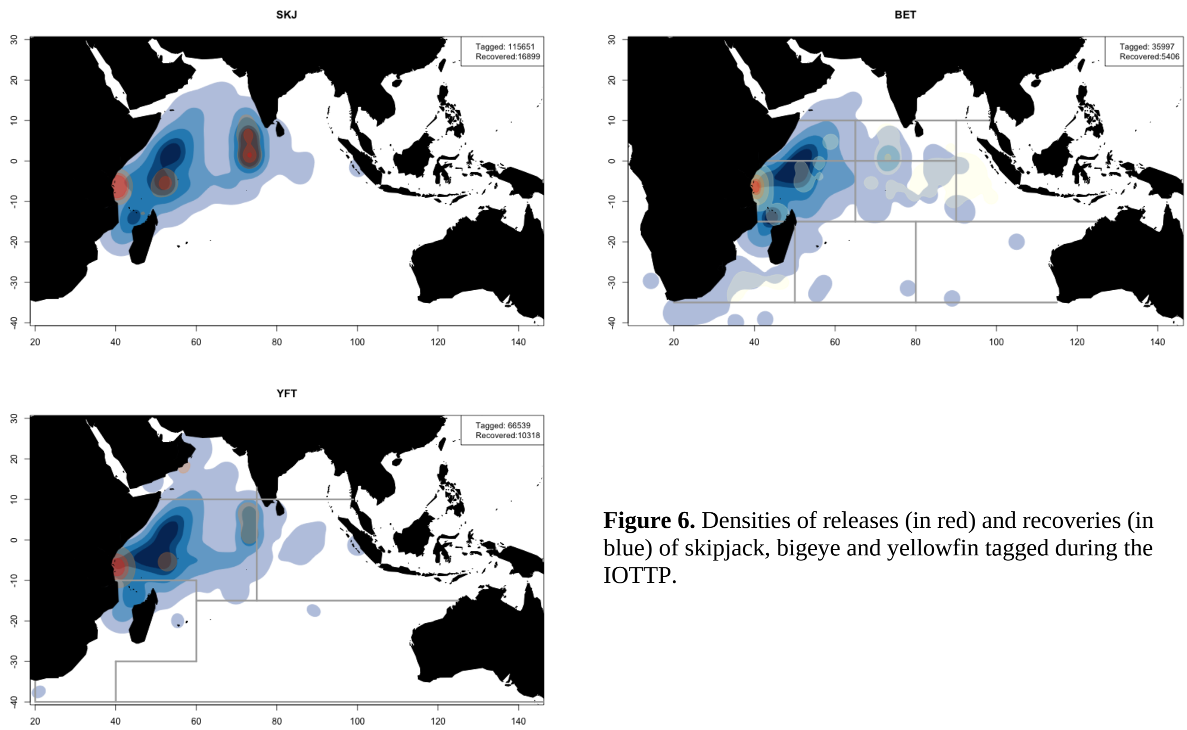


Figure 6. Densities of releases (in red) and recoveries (in blue) of skipjack, bigeye and yellowfin tagged during the IOTTP.

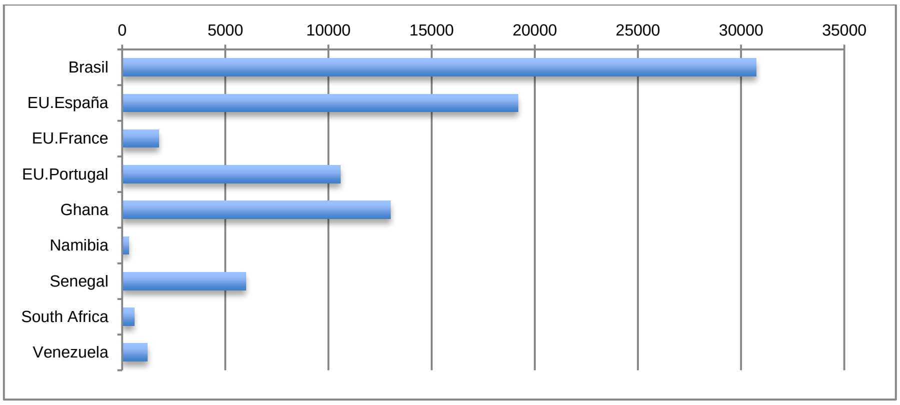
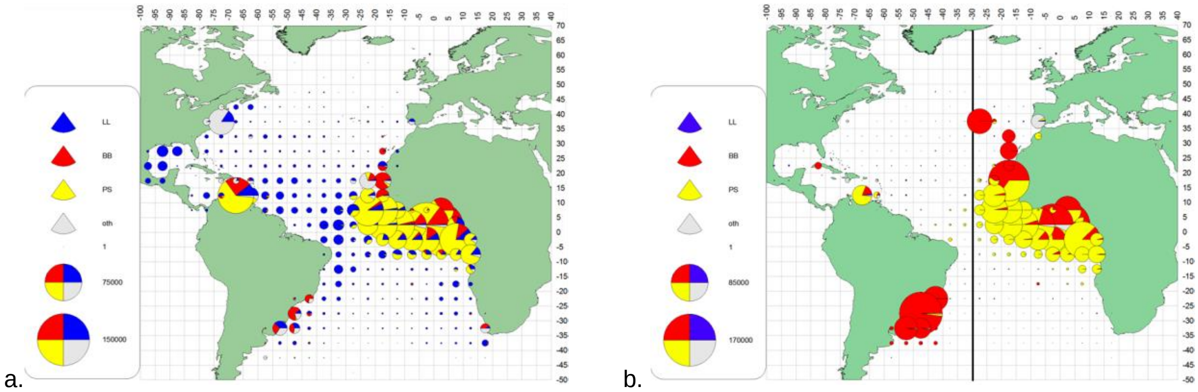


Figure 7. Baitboat catches (in tons) of tropical tunas (BET, SKJ and YFT) in 2011 per fleet.



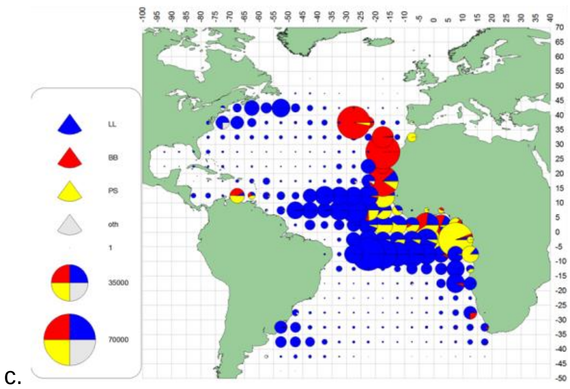


Figure 8. Spatial distribution of catches of a. yellowfin, b. skipjack and c. bigeye by major gear for the decade 2000-2009 (ICCAT, 2013b).

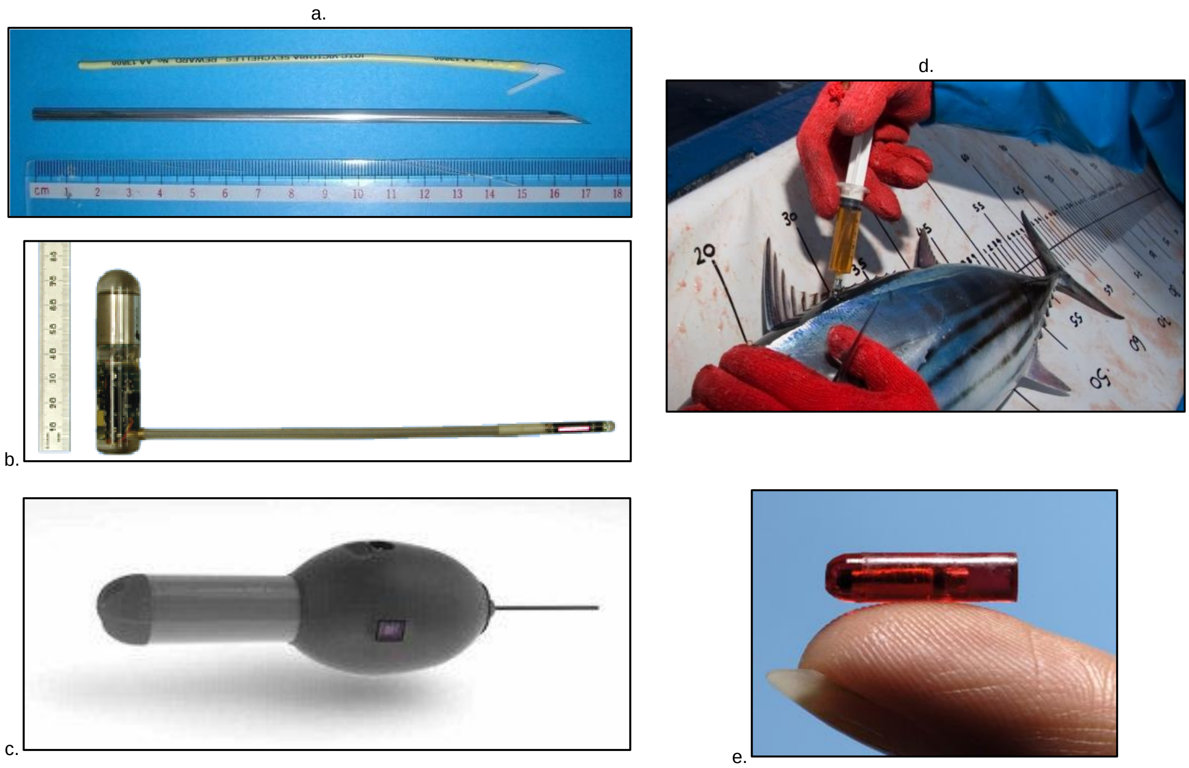


Figure 9. Different types of tags for different objectives, a. conventional spaghetti tag, b. archival tag, c. pop-up tag, d. chemical tagging, e. food safe RFID tag.

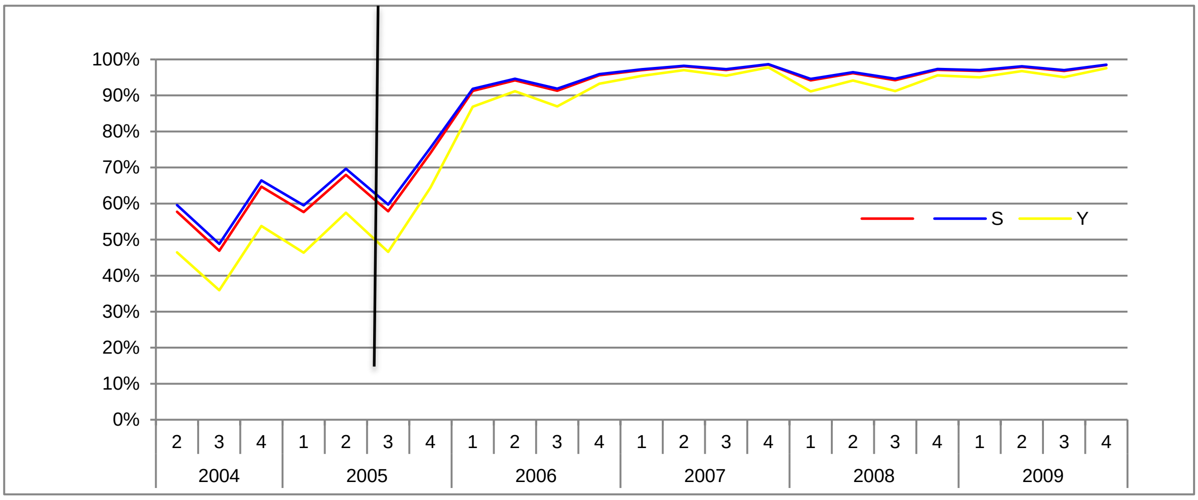


Figure 10. Reporting rates for the stevedores in Seychelles by species from 2004 to 2009.

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TRIAL ESTIMATION OF STANDARDIZED CATCH PER UNIT EFFORT OF YELLOWFIN TUNA BY THE TAIWANESE LONGLINE FISHERY IN THE TROPICAL WATERS OF THE ATLANTIC OCEAN

Chia-Lung Shih[1], Shih-Chin Chou[2], Hui-Yu Wang[1], Chien-Chung Hsu[1]

SUMMARY

The trial standardized catch per unit effort (CPUE) of Atlantic yellowfin tuna caught by Taiwanese longline fishery was estimated by general linear models (GLM). For the manipulation, several factors were used including year, quarter, subarea, vessel category and the two-way interactions. Before estimating CPUE, historical catch and effort data were selected and re-examined by spatial and temporal distribution in the tropical core fishing area; then the 1990-2011 catch and effort data within the tropical core area (15°N- 20°S) were selected and stratified into five subareas to make the nominal CPUE as homogeneous as possible among subareas by cluster analysis. The GLM and Delta-GLM were used to standardize yellowfin tuna CPUE for the Taiwanese longline fishery in the Atlantic tropical waters. The results obtained show a very similar trend except for the displacement of peaks in the series. Discrepancies occurred between the Japanese longline CPUE series and any one of the three Taiwanese series. Logically, the comparison suggests that the applicability of Standardized CPUE for yellowfin tuna by the Taiwanese longline fishery in the Atlantic Ocean warrants verification and refining before the stock assessment session.

RÉSUMÉ

La capture par unité d'effort (CPUE) standardisée expérimentale de l'albacore de l'Atlantique capturé par la pêcherie palangrière du Taipei chinois a été estimée par des modèles linéaires généralisés (GLM). Pour la manipulation, plusieurs facteurs ont été utilisés, y compris année, trimestre, sous-zone, catégorie de navires et interactions à double sens. Avant d'estimer la CPUE, les données historiques de prise et d'effort ont été sélectionnées et réexaminées par la distribution spatio-temporelle dans la zone de pêche centrale tropicale ; ensuite, les données de prise et d'effort de 1990-2011 à l'intérieur de la zone centrale tropicale (15°N- 20°S) ont été sélectionnées et stratifiées en cinq sous-zones pour rendre la CPUE nominale aussi homogène que possible parmi les sous-zones par analyse de groupement. Les GLM et Delta-GLM ont été utilisés pour standardiser la CPUE de l'albacore pour la pêcherie palangrière du Taipei chinois dans les eaux atlantiques tropicales. Les résultats obtenus montrent une tendance très similaire, sauf pour le déplacement des pics dans les séries. Des divergences sont apparues entre les séries de CPUE palangrière japonaise et n'importe laquelle des trois séries du Taipei chinois. Logiquement, la comparaison suggère que l'applicabilité de la CPUE standardisée pour l'albacore par la pêcherie palangrière du Taipei chinois opérant dans l'océan Atlantique doit être vérifiée et affinée avant la réunion d'évaluation du stock.

RESUMEN

Se estimó la captura por unidad de esfuerzo (CPUE) de prueba estandarizada del rabil del Atlántico capturado por la pesquería de palangre de Taipei chino mediante modelos lineales generalizados (GLM). Para la manipulación, se utilizaron varios factores, entre ellos, año, trimestre, subárea, categoría de buque y las interacciones en dos sentidos. Antes de estimar la CPUE, se seleccionaron los datos históricos de captura y esfuerzo y se volvieron a examinar mediante una distribución espacial y temporal en la zona de pesca central tropical, después se seleccionaron los datos de captura y esfuerzo de 1990-2011 dentro de la zona central tropical (15°N- 20°S) y se estratificaron en cinco subáreas para que la CPUE nominal fuera lo más homogénea posible en las diferentes zonas mediante un análisis de conglomeración. Se

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utilizaron GLM y Delta-GLM para estandarizar la CPUE de rabil para la pesquería de palangre de Taipei Chino en aguas tropicales del Atlántico. Los resultados obtenidos muestran una tendencia muy similar, con la excepción del desplazamiento de los picos de la serie. Las discrepancias se observaron entre las series de CPUE de la pesquería de palangre japonesa y cada una de las tres series de Taipei Chino. Lógicamente, la comparación sugiere que la aplicabilidad de la CPUE estandarizada para el rabil para la pesquería de palangre de Taipei Chino en el océano Atlántico requiere una verificación y mejora antes de la sesión de evaluación de stock.

KEYWORDS

Abundance indices, Fishery indicators, Yellowfin, Longline gear

1. Introduction

As usual, catch per unit effort (CPUE) is defined as catch divided by its effort used; and the dimension of catch and longline effort are in numbers (or in weight) and hooks, respectively. The standardized CPUE is frequently used as abundance index in the stock assessment, which is an important input value used when the population parameters are estimated in evaluating a population (Maunder and Punt 2004, Quinn and Deriso 1999).

Moreover, data used for standardizing CPUE are always obtained from catch and effort information of commercial fisheries, which are called fishery dependent data mostly provided by fishing stakeholders. Those data are recorded by fishing boat skippers and compiled by fishing authorities or its agents in charge. Thus, those data may have more or less variability in time and space due to the fishing targets, fish distributions and environmental factors. And consequently, estimates of fish abundance index may be influenced either by those factors; and also catchability may be varied. Subsequently, the nominal CPUE may not reflect the real abundance index as possible in efficacy. For reduce those effects on catchability, a procedure is to standardize the fishery dependent data to obtain standardized CPUE.

Several methods were used in standardizing CPUE (Hinton and Maunder 2004); and general linear models (GLMs) are the common ones frequently used (Maunder and Punt 2004). Those GLMs are extended to include, such as, general additive models (GAMs) (Hastie et al. 2001), general linear mixed models (GLMMs) (Pinheiro and Bates 2000), and others (Maunder and Punt 2004). Moreover, fishery dependent data were often encountered a number of zero catch, especially when the fishery is not to target the study species. The frequent way to prevent zero catch in logarithmic transformation of nominal CPUE in applying GLMs to standardize CPUE is to add a percentage of grand mean to nominal CPUE (Cao et al. 2011), or other error structures were applied, such as a Tweedie distribution (Shono 2008). Lo et al. (1992) claimed that a number of zero catch may result in uncertainty for standardized CPUE; thus in order to improve the declined effect of zero catch and to increase the accuracy of standardized CPUE, they suggested a delta lognormal error structure to be assumed in CPUE standardization models. And then, a delta GLM model was suggested to improve the flexibility of the delta lognormal model and the delta GLM was used to standardize the fishery dependent data into abundance index (Hill et al. 2007).

We are attempting to find a region where yellowfin tuna is targeted by Taiwanese longline fishery; to standardize yellowfin tuna abundance index within this selected region by delta GLM; and to compare the results estimated and reported previously (Hsu 2012; Satoh et al. 2012).

2. Materials and methods

2.1 Fishing region stratification

One of the important factors in standardizing CPUE is the stratification of larger fishing region into several smaller ones (Su et al. 2008), which is usually used in the Pacific Ocean. Yellowfin tuna distributes extensively in the Atlantic Ocean, and it is much abundant in the tropical waters. The fishing types used can be used to reflect the targets usually, hence, **Figure 1** points out that Taiwanese longline quarterly nominal CPUE distributions indicated that the major region of yellowfin tuna catch was within the tropical waters ((15oN – 20oS) (**Figure 1**) because the more hooks per basket (HPB) were used to target the tropical tunas. Therefore, the historical logbook data, obtained from the Overseas Fisheries Development Council (OFDC), may be extracted for the core part of yellowfin catches from the tropical waters.

2.2 Fishing effort and hooks per basket

According to the analysis of fishing effort used by Taiwanese longline fishery in logbooks submitted by fishing companies indicated that the reasonable hooks used to target tropical tunas (bigeye tuna and yellowfin tuna) per daily operation may be around 3,000 hooks (Hsu 2011), hence, a upper limit of hooks used per day would be set below 3,200 hooks; and further, hooks greater than 3,200 hooks, the daily fishing information in logbooks was deleted in the present analysis.

Moreover, the information of HPB may be an important factor in the standardization process, although several previous reports regarding to analyze hooks per basket may not be useful in CPUE analysis (Takeuchi 2001; Goodyear 2003; Bach et al. 2006). A trial including HPB as one of the factors was made in this analysis to analyze the effect between target species and HPB used by Taiwanese longline fishery.

2.3 Standardize catch per unit effort

2.3.1 Delta-GLM CPUE standardization methods

Standardized yellowfin tuna CPUE and other tunas and tuna-like species has been estimated previously by generalized linear model (GLM) approaches (e.g. Yokawa and Clark 2005; Bigelow 2006; Satoh et al. 2012). In the present study, an alternative delta-GLM (Lo et al. 1992) was applied in which the result is obtained by the multiplication between the separate estimates that the proportion of positive yellowfin tuna catches assuming a binomial error distribution, and the mean catch rate of positive catches by assuming a different error distribution such as lognormal distribution. The standardized CPUE index is the product of these models estimated components. The formulation of the delta GLM for both dataset 1 for proportion of positive catch (p) was

$$\log\left(\frac{p}{1-p}\right) = \mu + f_1 + f_2 + ... + error$$

and dataset 2 for the positive catch rate:

$$\log(CPUE_{ijkl}) = \mu + f_1 + f_2 + ... + error$$

where CPUEijkl is the catch in number per 1,000 hooks in year i, month j, gear k, area l and error represents the random error term under the effects of f_1, f_2, …, etc for year, month, gear, area, …, respectively. No interaction terms were considered without loss generality. Analyses were done using the R statistical computer software (R version 2.2.0), and a delta-GLM procedure obtained from E.J. Dick (NOAA Fisheries). Given the preferred error distribution without diagnosis of models, a step-wise regression procedure was used to determine the set of explanatory variables. The difference in deviance between two consecutive models was evaluated by Chi square and deviance analysis tables are presented for the data series, including the deviance for the proportion of positive observations and for positive catch rates.

2.3.2 GLM model used to standardize yellowfin tuna CPUE

Satoh et al. (2012) submitted a yellowfin tuna standardized CPUE by years and by quarterly series for representing Japanese longline fleet operating in the Atlantic Ocean. In their document, two standardization model were provided:

GLM model was used for the annual series with year, month, and sub-area as the fixed factor and year-month and year-subarea as two way interactions. The model was built and a lognormal error structure was used as:

$$\log(CPUE + c) = \mu + year + month + year * month + year * subarea + error$$

where c used 10% grand mean. And a GLM model was used for the standardized quarterly CPUE series with year (Y), quarter (q), latitude (Lat), and longitude (Lon) as the fixed factors and several interactions (Lat^p and Lon^p, where p for power with $p =$ 1, 2 and 3; and Q represents the sum of interactions

$Lat*Lon$, Lat^3*Lon, $Y*q$, $q*Lat$, $q*Lat^2$, $q*Lat^3$, $q*lon$ and $q*Lon^3$) with lognormal error structure (ε); and the formulas was:

$$\log(CPUE+c)=\mu+\Upsilon+q+\sum\left(Lat^p+Lon^p\right)+Q+\varepsilon$$

For comparing the consistency of yellowfin tuna abundance indices between Japanese and Taiwanese longline fleets, both methods were used to estimate yellowfin tuna abundance index for Taiwanese longline fishery in the Atlantic Ocean.

3. Results

3.1 Data used

Logbook data were used in the present trial examination of standardized CPUE for yellowfin tuna caught by Taiwanese longline fleet in the Atlantic Ocean. The data were provided by the Oversea Fisheries Development Council (OFDC) who is taking in charge of catch statistics compilation of Taiwanese longline fishery. Those data released include daily fishing information vessel by vessel within a 5 degree squared block. Information included vessel tonnage category, fishing date, hooks per basket (since 1995), total hooks used, sea surface temperature, catch in number and in weight by species, bait used (in occasion).

3.2 Hooks per basket, target species and fishing pattern

Analyzing the distribution of accumulated fishing days by hooks per basket indicated that there were two apparent modes, revealing that the target species is different in corresponding with these two modes (**Figures 2** and **3**). One of the modes represents the fishing vessels using less hooks per basket (8-11 hooks per basket) to target albacore mainly; and the rest represents more hooks per basket (15-18 hooks per basket) to target tropical tunas, such as bigeye tuna and yellowfin tuna. There are apparently in different fishing regions for those two fisheries using different HPB due to the habitats of temperate tunas and tropical tunas in the waters, in which the fishing waters for tropical tunas mainly in the tropical waters; and for temperate tunas in the waters of high latitudes (**Figure 1**).

Further, Examining spatial and temporal distribution of catch for yellowfin tuna, fishing effort and nominal CPUE in quarterly 5-degree squared area for Taiwanese longline fishery in the Atlantic Ocean, indicating that the major region of yellowfin tuna for this fleet is in the tropical waters (15oN-20oS). And apparently, there were significantly fishing effort occurred in the tropical waters after 1990 onward. In the present trial estimation of abundance index of yellowfin tuna, the fishing activities and fishery dependent data within tropical waters were extracted to standardize CPUE after 1990.

3.3 Stratification of fishing regions

The fishing region of yellowfin tuna in the tropical waters of Atlantic Ocean was stratified into 5 sub-areas in according to the HPB composition (**Figure 1**), spawning ground of yellowfin tuna and fishing patterns of vessels. The 5 stratified regions were depicted in **Figure 4. Figure 4** indicated accordingly, that sub-area 1 located northwestern waters had less fishing efforts operation historically; sub-area 2 in the central north waters of tropical Atlantic Ocean was the major fishing ground of Taiwanese longline fleet and caught bigeye tuna and yellowfin tuna mainly; Sub-area 3 in the northeastern region of tropical waters was the spawning ground of yellowfin tuna, there are heavy fishing effort suffered in this sub-area; sub-area 4 in the central equatorial waters of the south latitude, the proportion of low HPB and albacore catch is high (**Figure 1**), and mainly the conventional longline fleet operated in this sub-area; and sub-area 5 in the southeast waters, whereas the albacore catch was also high, and this waters within 15oS-20oS is mainly conditional longline fleet operation (**Figure 4**).

3.4 Nominal catch per unit effort

1990-2011nomial CPUE of yellowfin tuna by Taiwanese longline fleet in the tropical Atlantic waters showed a decreasing tendency (**Figure 5**). The series decreased from 2.03 ind./1000 hooks in 1990 to 1.40 ind./1000 hooks in 1993, this decreasing during inception period may reflected the transferring of the traditional albacore target to tropical species target by Taiwanese longline fleet. The series then increased to 3.49 ind/1000 hooks in 1994, and decreasing from 3.01 ind./1000 hooks in 1995 to 0.54 ind./1000 hooks in 2001; and increased to 1.76 ind./1000 hooks in 2005; thereafter a fluctuated decreasing between 0.28 ind./1000 hooks and 0.68 ind./1000 hooks from 2005 onward to 2011.

3.5 Standardized catch per unit effort

The nominal CPUE series was standardized by delta GLM. A total of 191,430 1990-2011 data records was extracted for positive yellowfin tuna catch; and among those data extracted, a total of 93,575 data records (49%) were found with at least one yellowfin tuna caught. First of all, the positive yellowfin tuna CPUE was estimated with analyzing effect of factors selected for the standardization purpose. The results, in **Table 1**, indicate that all factors are significant at 5% level except season factor (quarter). However, the two-way interactions between season and other fixed factors are in statistical significance ($p<0.05$); subsequently, the season factor was used also in the standardization model. Under the assumption of log-normal error distribution, the GLM model was pursued. The ANOVA table for the standardization positive yellowfin tuna CPUE was tabulated in **Table 2**, indicating that all factors are significant at 5%. Then parameters of standardizing positive yellowfin tuna CPUE was shown in **Table 3**. Also the residuals distribution of model fitting and Q-Q plot was illustrated in **Figure 6**, revealing that the residuals distribution may be similar to a normal distribution and the Q-Q plot also looks approximately 1:1, although the diagnosis was not fully satisfied as normal distribution as logarithmic transformation. The error assumption in GLM model of standardizing the positive yellowfin tuna CPUE may not be much reasonable as expected.

Further the standardization was made to the proportion of yellowfin tuna positive catch. The factors that will be used to standardize positive catch was evaluated by stepwise regression again; and the results in **Table 4** indicated that the variability of only year and sub-area are significant ($p<0.05$). Thus, the two fixed factors were selected to standardize the proportion of positive yellowfin tuna catch in GLM. Under the assumption of binomial distribution error structure, The ANOVA table (**Table 5**) was indicated that this two factors are significant ($p<0.05$) to the GLM in standardizing proportion of positive yellowfin tuna catch. Then, parameters of standardizing proportion of yellowfin tuna catch were shown in **Table 6**. We are not expected the residuals distribution as a normal distribution but binomial distribution that was assumed for the standardized model for the proportion of positive catch. Thus the Q-Q plot and histogram for the residuals distribution, as in **Figure 7**, indicated that the residuals distributes randomly and dispersed symmetrically on the both sides of zero mean as it is in the assumption as the binomial distribution.

Therefore the standardized yellowfin CPUE was obtained by the product of the standardized positive yellowfin tuna catch and proportion of positive yellowfin tuna catch; and illustrated in **Figure 8**, indicating that the time series is increasing from 1990 – 1992 (under 1.0 ind./1000 hooks) to about 2.11 ind./1000 hooks in 1994, and then decreasing to about 0.62 ind./1000 hooks in 1998, and fluctuation around the low values below 0.62 ind./1000 hooks. To compare with result of Hsu (2012) as shown in **Figure 9**, the result in the present study is apparently different with the result estimated in Hsu (2012), which the overall catch data in entire Atlantic Ocean were used.

3.6 Standardization of yellowfin tuna by Taiwanese longline fleet using Japanese models

Without any factor examination, the models used in standardizing CPUE of yellowfin tuna by Japanese longline fleet (Satoh et al. 2012) were applied in the current study. The GLM used year, month, and two way interactions of year and month, year and subarea as factor to standardize yearly series in number and in weight; and factor and interactions were used in the standardization of quarterly series. The ANOVA tables were shown in the **Tables 7, 8,** and **9**, respectively. Factors used to standardize yearly series are all significant ($p<0.5$); and some of factors used to standardize quarterly were not ($p>0.5$) and were omitted in GLM.

Under the factors used in GLM, the standardized CPUE for yearly and quarterly series were estimated. And the models were evaluated for error structure assumed by Q-Q plots and residuals histogram distribution, illustrated in **Figures 10, 11**, and **12**, respectively. All those examinations indicated the distributions are approximately consistent to normal distribution but the left skewness and double peaks are performed. And then, the yearly standardized CPUE in number and weight and quarterly standardized CPUE in number were estimated as in **Figure 13**, although the diagnosis of error assumption in visual shows that the assumption may not fully suitable for the detection of the error of the used data set distributed randomly.

3.7 Comparison of standardized CPUE

Comparison was made visually as in **Figure 14** among the time series of standardized yellowfin tuna CPUEs by Taiwanese longline fleet, which were standardized by delta GLM, GLM with factors as Satoh et al. (2012); GLM (Hsu 2012); and the Japanese longline fleet (Satoh et al. 2012). Roughly, series with delta GLM standardization indicated one major peak and a minor peak, which are 1994-1996 and 2002-2005, respectively. Series standardized by GLM with factors similar to Japanese longline series (Satoh et al. 2012) shows a year displacement for the major peak; and 2003-2005 for the minor peak, which was a tendency similar to Hsu (2012). However, all those series reveal a very different tendency with Japanese longline series.

All of the standardized CPUEs of yellowfin tuna for Taiwanese longline fleet in the Atlantic Ocean are listed with 95% confidence intervals in **Appendix Tables I, II, III** and **IV** in different measurements and time frames.

4. Discussion

Taiwanese longline fleets are composed of deep sea longline fleet and offshore longline fleet, which are operated in the three oceans. The offshore longline fleet targets multispecies in season and in occasion, but mainly targets yellowfin tuna in the deep sea; and the deep sea longline fleet targets tunas and tuna-like species, which the deep sea longliners are composed of the conventional longline fleet to target mainly albacore, and the super-cold longline fleet to target the tropical species, mainly bigeye tuna, and yellowfin tuna as incidental catch.

The current study used almost the data submitted by deep longline fleet. And the standardized method used was the model used for a significant zero catch (Lo et al. 1992) within the dataset, although other methods were used, such as Shono (2008). And the comparison was made among the resultant longline CPUEs visually from the Atlantic Ocean.

Yellowfin tuna is the third high catch by Taiwanese longline fleet in the Atlantic Ocean right behind catches of bigeye tuna and albacore in order. Two periods can roughly stratified for the change of fishing patterns of Taiwanese longline fleet in the Atlantic Ocean. The fishery has been transferred to target tropical bigeye tuna since 1990. This is why the time frame was set to start from 1990 in the trial study. And only the tropical waters was selected because yellowfin tuna is one of the tropical species, although yellowfin tuna can be also caught by the conventional longline fleet incidentally that targets always albacore in the temperate waters. During the present analysis, we also found a significant operation of Taiwanese longline fleet in the tropical water (**Figure 1**) from all the way of time series of 1981-1984. Moreover, we also found in the fishing effort for the fleet, which was suffered in the eastern tropical waters in the Atlantic Ocean; and the catches of yellowfin tuna were less than 1,000 t (Hsu 2012). Therefore, we assumed that the data of yellowfin tuna in the tropical fishing region after 1990 may be an eligible representative CPUE for the entire Atlantic Ocean.

Delta GLM is one of the models used to standardize CPUE (Anon. 2011), especially for the data with significant zero catch (Lo et al. 1992), such as Taiwanese catch data of yellowfin tuna (about 51% are zero catch) in the Atlantic Ocean. The result seems not concordant with the series estimated before (Hsu 2012), however, the tendency is similar except those in 1994 and 1995. Comparison to the standardized CPUE series of Japanese longline fleet (Satoch et al. 2012) indicated that both series were in different trends. Thus, it is necessary to re-verify the original daily logbooks before standardizing catch per unit effort for using as abundance index in the stock assessment, and the species is not limited to yellowfin tuna, other species, such as bigeye tuna, albacore, swordfish etc. are also necessary to validate their logic in future.

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Table 1. Total deviance of positive CPUE for yellowfin tuna caught by Taiwanese longline fishery operating in the tropics of Atlantic Ocean.

	DF	SS	Change deviance	% total deviance
Intercept	93573	101596.07		
Year	93552	88698.27	12897.80	14.54*
Year+q	93549	88585.88	112.39	0.13
Year+q+subarea	93545	82366.95	6218.93	7.55*
Year+q+subarea+CT	93542	82217.10	6368.78	7.75*
Year+q+subarea+CT+Year*q	93479	80598.99	7986.90	9.91*
Year+q+subarea+CT+Year*q+Year*subarea	93397	77906.00	10679.88	13.71*
Year+q+subarea+CT+Year*q+Year*subarea+Year*CT	93361	76880.17	5486.78	7.14*
Year+q+subarea+CT+Year*q+Year*subarea+Year*CT+q*subarea	93349	76339.96	12245.92	16.04*
Year+q+subarea+CT+Year*q+Year*subarea+Year*CT+q*subarea+subarea*CT	93340	76249.19	12336.69	16.18*

Note. q: season. CT: CT number of longliner. Subarea: the divided area. Stars indicate proportion of total deviance is above 5%.

Table 2. Results of ANOVA table for positive CPUE standardization by general linear model

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	233	25346.9	108.785	133.17	<.0001
Error	93340	76249.2	0.8169		
Corrected Total	93573	101596			

R-Square	**Coeff Var**	**Root MSE**	**logcpue Mean**
0.249487	410.297	0.90382	0.22029

Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Year	21	1908.12	90.863	111.23	<.0001
q	3	35.4473	11.8158	14.46	<.0001
subarea	4	38.9026	9.72565	11.91	<.0001
CT	3	46.9487	15.6496	19.16	<.0001
Year*q	63	1074.47	17.055	20.88	<.0001
Year*subarea	79	1921.77	24.3262	29.78	<.0001
Year*CT	36	930.351	25.8431	31.64	<.0001
q*subarea	12	524.48	43.7066	53.5	<.0001
subarea*CT	9	90.7674	10.0853	12.35	<.0001

Table 3. Parameters of positive CPUE for yellowfin tuna caught by Taiwanese longline fishery operating in the tropics of Atlantic Ocean standardized by GLM.

Analysis Of Parameter Estimates								
Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits	Wald 95% Confidence Limits	Chi-Square	Pr > ChiSq
Intercept		1	-0.5297	0.0385	-0.6051	-0.4543	189.65	<.0001
Year	1990	1	0.7633	0.1988	0.3737	1.1529	14.74	0.0001
Year	1991	1	1.0077	0.1981	0.6195	1.396	25.88	<.0001
Year	1992	1	0.7791	0.2709	0.2483	1.31	8.27	0.004
Year	1993	1	1.0149	0.079	0.8601	1.1697	165.13	<.0001
Year	1994	1	1.8023	0.0697	1.6656	1.9389	668.41	<.0001
Year	1995	1	1.6766	0.0494	1.5798	1.7734	1152.37	<.0001
Year	1996	1	0.8193	0.049	0.7234	0.9153	280.1	<.0001
Year	1997	1	0.4711	0.0515	0.3701	0.5722	83.56	<.0001
Year	1998	1	0.8011	0.0553	0.6927	0.9095	209.86	<.0001
Year	1999	1	0.3	0.046	0.2099	0.3902	42.52	<.0001
Year	2000	1	0.434	0.0501	0.3357	0.5323	74.92	<.0001
Year	2001	1	0.0695	0.0663	-0.0604	0.1995	1.1	0.2943
Year	2002	1	0.7952	0.0556	0.6862	0.9042	204.45	<.0001
Year	2003	1	0.6806	0.0571	0.5686	0.7926	141.91	<.0001
Year	2004	1	0.8492	0.048	0.7552	0.9432	313.48	<.0001
Year	2005	1	0.6067	0.0459	0.5168	0.6967	174.64	<.0001
Year	2006	1	0.0177	0.0741	-0.1276	0.163	0.06	0.8118
Year	2007	1	-0.2847	0.0546	-0.3918	-0.1776	27.16	<.0001
Year	2008	1	-0.0875	0.0578	-0.2008	0.0258	2.29	0.1302
Year	2009	1	-0.0947	0.0544	-0.2014	0.012	3.03	0.0819
Year	2010	1	-0.1915	0.0525	-0.2943	-0.0886	13.31	0.0003
Year	2011	0	0	0	0	0	.	.

Table 4. Total deviance of proportion of positive catch sets for yellowfin tuna caught by Taiwanese longline fishery operating in the tropics of Atlantic Ocean, in which q is the season by calendar quarter, CT is the vessel categories, and subarea is the stratified areas as indicated in **Figure 5**.

	DF	SS	Change deviance	% total deviance
Intercept	9823	615.29		
Year	9802	555.95	59.33	10.67*
Year+q	9799	552.23	3.73	0.67
Year+q+subarea	9795	503.79	48.44	9.61*
Year+q+subarea+CT	9792	499.67	4.13	0.83
Year+q+subarea+CT+Year*q	9729	487.09	12.58	2.58
Year+q+subarea+CT+Year*q+Year*subarea	9646	465.24	21.85	4.70
Year+q+subarea+CT+Year*q+Year*subarea+Year*CT	9609	460.18	5.05	1.10
Year+q+subarea+CT+Year*q+Year*subarea+Year*CT+q*subarea	9597	452.45	7.73	1.71
Year+q+subarea+CT+Year*q+Year*subarea+Year*CT+q*subarea+subarea*CT	9588	451.54	0.91	0.20

*indicate proportion of total deviance is significant at 5%.

Table 5. Results of ANOVA table for positive catch sets standardization by general linear model

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	25	107.89	4.31559	83.34	<.0001
Error	9798	507.399	0.05179		
Corrected Total	9823	615.289			
R-Square	**Coeff Var**	**Root MSE**	**Logppp Mean**		
0.18	57.67	0.23	0.39		
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Year	21	53.915	2.56738	49.58	<.0001
subarea	4	48.5559	12.139	234.41	<.0001

Table 6. Parameters of proportion of positive catch sets for yellowfin tuna caught by Taiwanese longline fishery operating in the tropics of Atlantic Ocean standardized by GLM.

Analysis Of Parameter Estimates								
Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits	Wald 95% Confidence Limits	Chi-Square	Pr > ChiSq
Intercept		1	-0.9479	0.0174	-0.982	-0.9138	2965.8	<.0001
Year	1990	1	1.4302	0.0695	1.294	1.5665	423.15	<.0001
Year	1991	1	1.189	0.0828	1.0266	1.3513	206.1	<.0001
Year	1992	1	1.2519	0.0938	1.068	1.4359	177.95	<.0001
Year	1993	1	1.0145	0.0562	0.9042	1.1247	325.35	<.0001
Year	1994	1	1.3214	0.0475	1.2283	1.4145	774.3	<.0001
Year	1995	1	1.6247	0.0354	1.5553	1.6941	2105.4	<.0001
Year	1996	1	1.3604	0.0278	1.3059	1.4149	2395.4	<.0001
Year	1997	1	0.3171	0.0249	0.2682	0.366	161.58	<.0001
Year	1998	1	-0.0189	0.0264	-0.0705	0.0328	0.51	0.4742
Year	1999	1	0.4828	0.0233	0.4372	0.5285	429.39	<.0001
Year	2000	1	0.7696	0.0253	0.72	0.8192	926.23	<.0001
Year	2001	1	0.2653	0.0296	0.2074	0.3233	80.53	<.0001
Year	2002	1	0.5724	0.0272	0.5191	0.6258	442.47	<.0001
Year	2003	1	1.0558	0.0311	0.9949	1.1168	1153.9	<.0001
Year	2004	1	0.6392	0.0243	0.5916	0.6868	692.82	<.0001
Year	2005	1	1.0071	0.024	0.9601	1.0541	1764	<.0001
Year	2006	1	0.8238	0.0407	0.744	0.9036	409.6	<.0001
Year	2007	1	0.3759	0.0256	0.3258	0.4261	215.96	<.0001
Year	2008	1	0.0077	0.0267	-0.0446	0.06	0.08	0.7735
Year	2009	1	0.0699	0.0238	0.0232	0.1166	8.61	0.0033
Year	2010	1	-0.4078	0.0242	-0.4553	-0.3602	282.8	<.0001
Year	2011	0	0	0	0	0	.	.

Table 7. Results of ANOVA table for CPUE (number) standardization by general linear model

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	350	88089.3	251.684	158.62	<.0001
Error	191078	303189	1.5867		
Corrected Total	191428	391278			
R-Square	**Coeff Var**	**Root MSE**	**LogMean**		
0.225132	-133.03	1.25965	-0.9469		
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Year	21	12184.9	580.235	365.68	<.0001
Month	11	751.079	68.2799	43.03	<.0001
Year*subarea	87	28593.4	328.66	207.13	<.0001
Year*Month	231	10301.1	44.5935	28.1	<.0001

Table 8. Results of ANOVA table for CPUE (weight) standardization by general linear model

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	350	81312.9	232.323	140.61	<.0001
Error	191078	315701	1.6522		
Corrected Total	191428	397014			
R-Square	**Coeff Var**	**Root MSE**	**Logppp Mean**		
0.20481	47.3797	1.28538	2.71295		
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Year	21	11180.9	532.424	322.25	<.0001
Year*subarea	11	719.335	65.3941	39.58	<.0001
Year*Month	87	26258.9	301.827	182.68	<.0001
Month*subarea	231	10856.2	46.9965	28.44	<.0001

Table 9. Results of ANOVA table for CPUE (quarter) standardization by general linear model

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	110	78593.3	714.485	437.16	<.0001
Error	191318	312685	1.6344		
Corrected Total	191428	391278			
R-Square	**Coeff Var**	**Root MSE**	**Logppp Mean**		
0.20086	-135.01	1.27843	-0.9469		
Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Year	21	28665.1	1365	835.18	<.0001
q	3	1020.99	340.33	208.23	<.0001
Lat	1	45.9052	45.9052	28.09	<.0001
Lon	1	3.72195	3.72195	2.28	0.1313
Lat_2	1	42.9979	42.9979	26.31	<.0001
Lon_2	1	4.13954	4.13954	2.53	0.1115
Lat_3	1	233.209	233.209	142.69	<.0001
Lon_3	1	29.1143	29.1143	17.81	<.0001
Lat*Lon	1	970.05	970.05	593.53	<.0001
Lon*Lat_2	1	1136.16	1136.16	695.17	<.0001
Year*q	63	5621.95	89.2374	54.6	<.0001
Lat*q	3	413.978	137.993	84.43	<.0001
Lat_2*q	3	296.999	98.9998	60.57	<.0001
Lat_3*q	3	285.413	95.1378	58.21	<.0001
Lon*q	3	234.3	78.1001	47.79	<.0001
Lon_3*q	3	778.881	259.627	158.85	<.0001

Appendix Table I. Yearly series standardized catch per unit effort (in No/1000 hooks) of yellowfin tuna caught by Taiwanese longline fleet in the Atlantic Ocean.

Year	cpue_p	cpue_95%lower	cpue_95%upper
1990	0.7810	0.4581	1.3224
1991	0.9032	0.5186	1.5583
1992	0.7384	0.3650	1.4768
1993	0.8393	0.6201	1.1299
1994	2.1146	1.6208	2.7478
1995	2.0875	1.6950	2.5647
1996	0.8038	0.6531	0.9874
1997	0.3276	0.2599	0.4122
1998	0.3614	0.2824	0.4619
1999	0.3066	0.2472	0.3797
2000	0.4140	0.3322	0.5150
2001	0.2119	0.1622	0.2763
2002	0.5310	0.4189	0.6719
2003	0.6128	0.4852	0.7722
2004	0.5828	0.4690	0.7231
2005	0.5560	0.4527	0.6818
2006	0.2811	0.2118	0.3717
2007	0.1598	0.1261	0.2022
2008	0.1515	0.1178	0.1946
2009	0.1572	0.1237	0.1996
2010	0.0996	0.0781	0.1270
2011	0.1645	0.1488	0.1817

Appendix Table II. *Yearly series standardized catch per unit effort (in kg/1000 hooks) of yellowfin tuna caught by Taiwanese longline fleet in the Atlantic Ocean.

Year	cpue_p	cpue_95%lower	cpue_95%upper
1990	32.36	18.98	54.79
1991	31.27	17.95	53.95
1992	26.61	13.15	53.22
1993	27.21	20.10	36.63
1994	58.00	44.46	75.37
1995	65.70	53.34	80.71
1996	27.40	22.27	33.66
1997	12.47	9.90	15.70
1998	13.17	10.29	16.83
1999	10.92	8.80	13.52
2000	14.10	11.32	17.54
2001	8.27	6.33	10.79
2002	19.51	15.39	24.68
2003	25.18	19.94	31.74
2004	21.88	17.60	27.14
2005	22.54	18.35	27.64
2006	14.21	10.71	18.79
2007	8.50	6.70	10.76
2008	7.58	5.89	9.73
2009	8.05	6.33	10.21
2010	4.53	3.55	5.77
2011	7.31	6.61	8.08

Appendix Table III. Annual yellowfin CPUE in number (left) and in weight (right) standardized for all Atlantic from 1990 to 2011 by expressing in real scale and relative scale in which the average from 1990 to 2011 is 1.0.

	CPUE in number			CPUE in weight		
Year	real scale	relative scale	CV	real scale	relative scale	CV
1990	0.54654	1.23	0.131848	20.6581	1.26	0.003559
1991	0.32319	0.73	1.029271	12.7418	0.78	0.026641
1992	0.47049	1.06	0.301175	19.3454	1.18	0.007474
1993	0.68664	1.55	0.140001	24.6652	1.50	0.003977
1994	0.93011	2.10	0.04693	30.1824	1.84	0.001476
1995	1.12566	2.54	0.021383	34.9091	2.13	0.000704
1996	0.87637	1.98	0.020311	32.3083	1.97	0.000562
1997	0.4341	0.98	0.039069	15.5178	0.95	0.001115
1998	0.3446	0.78	0.051364	11.5949	0.71	0.001558
1999	0.29478	0.67	0.042608	10.9509	0.67	0.001171
2000	0.38257	0.86	0.035366	13.3517	0.81	0.001034
2001	0.20249	0.46	0.101635	7.62	0.46	0.002757
2002	0.31188	0.70	0.0766	11.1856	0.68	0.00218
2003	0.45323	1.02	0.075458	17.3976	1.06	0.002006
2004	0.4175	0.94	0.040335	15.9554	0.97	0.001077
2005	0.79067	1.78	0.018946	31.285	1.91	0.000489
2006	0.33231	0.75	0.137582	14.7323	0.90	0.003167
2007	0.28296	0.64	0.141716	12.9455	0.79	0.003161
2008	0.14444	0.33	0.21933	6.493	0.40	0.004979
2009	0.14764	0.33	0.254606	6.5559	0.40	0.005851
2010	0.11595	0.26	0.223286	4.591	0.28	0.005755
2011	0.1363	0.31	0.266838	5.5728	0.34	0.006659

Appendix Table IV Annual yellowfin CPUE in number (quarter) standardized for all Atlantic from 1990 to 2011 by expressing in real scale and relative scale in which the average from 1990 to 2011 is 1.0.

		CPUE in number		
Year	quarter	Real scale	relative scale	CV
1990	1	0.70664	1.620511	0.103985
1990	2	0.55092	1.263404	0.164924
1990	3	0.73571	1.687176	0.112123
1990	4	0.56474	1.295097	0.102383
1991	1	0.76802	1.761271	0.083318
1991	2	0.46574	1.068064	0.340834
1991	3	0.31853	0.730473	0.711173
1991	4	0.63088	1.446773	0.136698
1992	1	0.43446	0.996331	0.158956
1992	2	0.36727	0.842246	0.297901
1992	3	0.57449	1.317456	0.243886
1992	4	2.53589	5.815461	0.054829
1993	1	0.83199	1.907971	0.109629
1993	2	0.53616	1.229556	0.21529
1993	3	0.33113	0.759368	0.214991
1993	4	0.47606	1.09173	0.092467
1994	1	0.75201	1.724556	0.065132
1994	2	0.52637	1.207105	0.132378
1994	3	0.52828	1.211485	0.107235
1994	4	1.3445	3.083291	0.030093
1995	1	1.45697	3.341215	0.030042
1995	2	0.58	1.330092	0.101448

1995	3	0.65458	1.501124	0.053424
1995	4	1.07325	2.461244	0.022036
1996	1	1.11583	2.558891	0.021455
1996	2	0.36835	0.844723	0.083589
1996	3	0.42707	0.979384	0.059733
1996	4	0.80076	1.836353	0.02871
1997	1	0.44252	1.014814	0.047139
1997	2	0.16915	0.387905	0.158439
1997	3	0.2125	0.487318	0.117976
1997	4	0.24704	0.566528	0.096907
1998	1	0.27515	0.630991	0.080429
1998	2	0.15161	0.347682	0.188246
1998	3	0.17486	0.401	0.163845
1998	4	0.18077	0.414553	0.134591
1999	1	0.28582	0.65546	0.070149
1999	2	0.18935	0.434229	0.121468
1999	3	0.24898	0.570976	0.090971
1999	4	0.22411	0.513943	0.087323
2000	1	0.43352	0.994175	0.04475
2000	2	0.27574	0.632344	0.09237
2000	3	0.33015	0.757121	0.088414
2000	4	0.23088	0.529468	0.112353
2001	1	0.1983	0.454754	0.118154
2001	2	0.21817	0.500321	0.145987
2001	3	0.15084	0.345916	0.270949
2001	4	0.15206	0.348713	0.236288
2002	1	0.27392	0.62817	0.077577
2002	2	0.24148	0.553777	0.108166
2002	3	0.33994	0.779572	0.101812
2002	4	0.5696	1.306242	0.065327
2003	1	0.73806	1.692565	0.037057
2003	2	0.66872	1.53355	0.047823
2003	3	0.37825	0.867427	0.098453
2003	4	0.52466	1.203183	0.071589
2004	1	0.39244	0.899968	0.053817
2004	2	0.45726	1.048617	0.053777
2004	3	0.4348	0.99711	0.056808
2004	4	0.40467	0.928014	0.054439
2005	1	0.48159	1.104412	0.040574
2005	2	0.86094	1.974361	0.026564
2005	3	0.61995	1.421708	0.038987
2005	4	0.59037	1.353873	0.038264
2006	1	0.52936	1.213961	0.075846
2006	2	0.3349	0.768014	0.150015
2006	3	0.36982	0.848094	0.135444
2006	4	0.39353	0.902468	0.125098
2007	1	0.35331	0.810233	0.085279
2007	2	0.40358	0.925515	0.063977
2007	3	0.20616	0.472779	0.11753
2007	4	0.13611	0.312136	0.167291
2008	1	0.22937	0.526006	0.094781
2008	2	0.15301	0.350892	0.161166
2008	3	0.17702	0.405953	0.208225
2008	4	0.12518	0.287071	0.212254
2009	1	0.22361	0.512796	0.093824
2009	2	0.21321	0.488946	0.101121
2009	3	0.09387	0.215269	0.249707

2009	4	0.13629	0.312549	0.156725
2010	1	0.1369	0.313948	0.141344
2010	2	0.11673	0.267693	0.182815
2010	3	0.11583	0.265629	0.210999
2010	4	0.0947	0.217172	0.204541
2011	1	0.17741	0.406848	0.105293
2011	2	0.16797	0.385199	0.118354
2011	3	0.15371	0.352497	0.139223
2011	4	0.10693	0.245219	0.182736

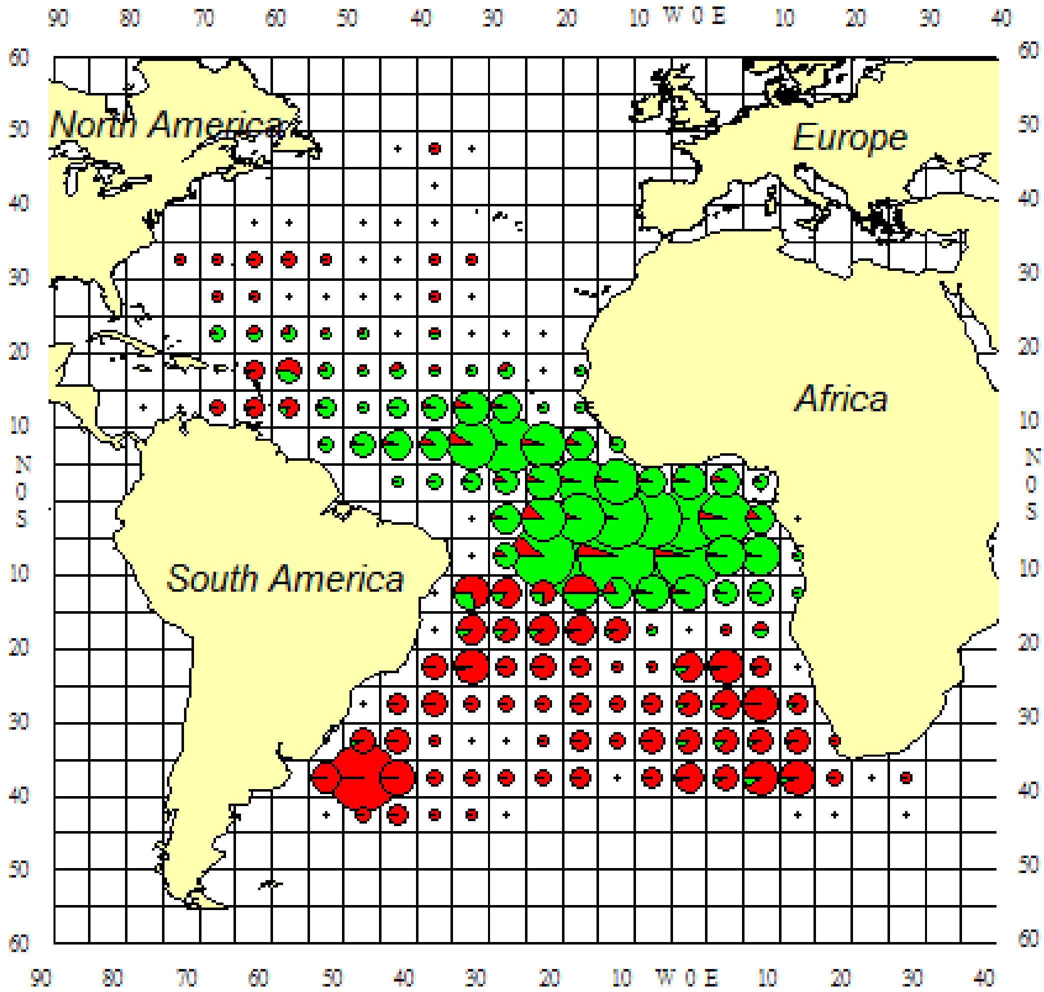


Figure. 1. Distributions of fishing type of Taiwanese longline fishery in the Atlantic Ocean from 1995-2011. (Green indicates targeting on bigeye tuna and red indicates targeting on albacore).

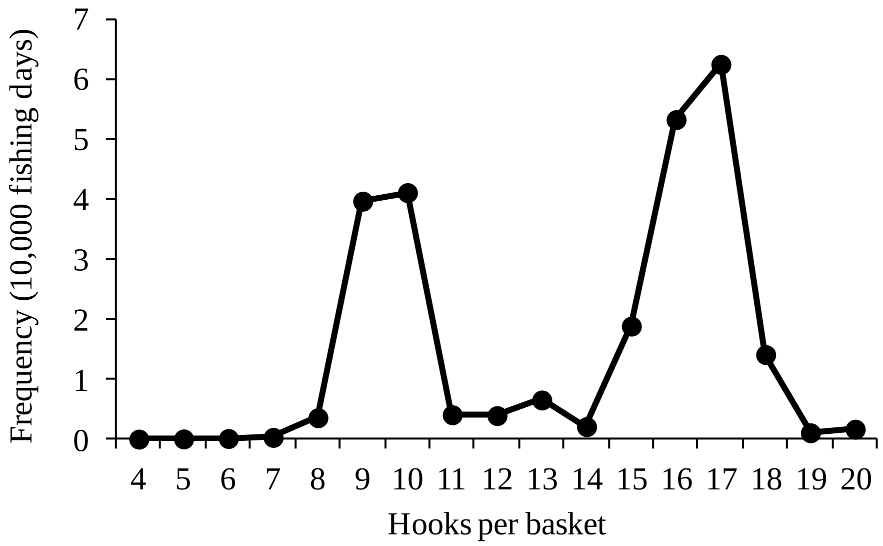


Figure 2. Distributions of cumulative fishing days by hooks per basket for Taiwanese longline fishery in the Atlantic Ocean during 1995-2011.

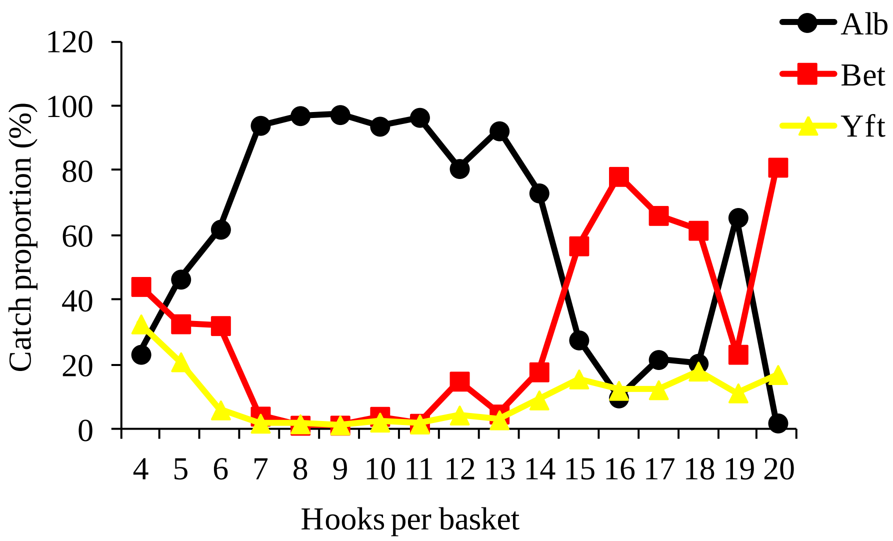


Figure 3. Distributions of catch species composition byhooks per basket for Taiwanese longline fishery in the Atlantic Ocean during 1995-2011.

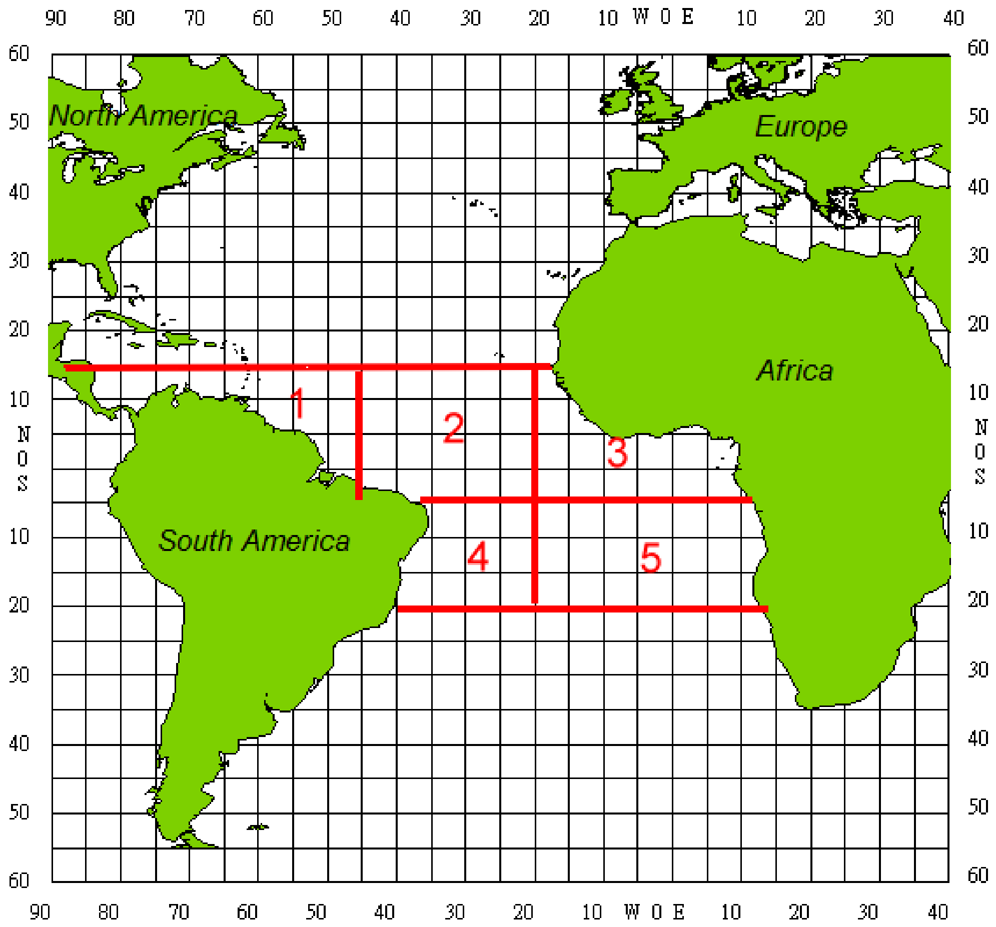


Figure 4. Five divided subareas based on Taiwanese longline fishery data operating in the tropics of the Atlantic Ocean.

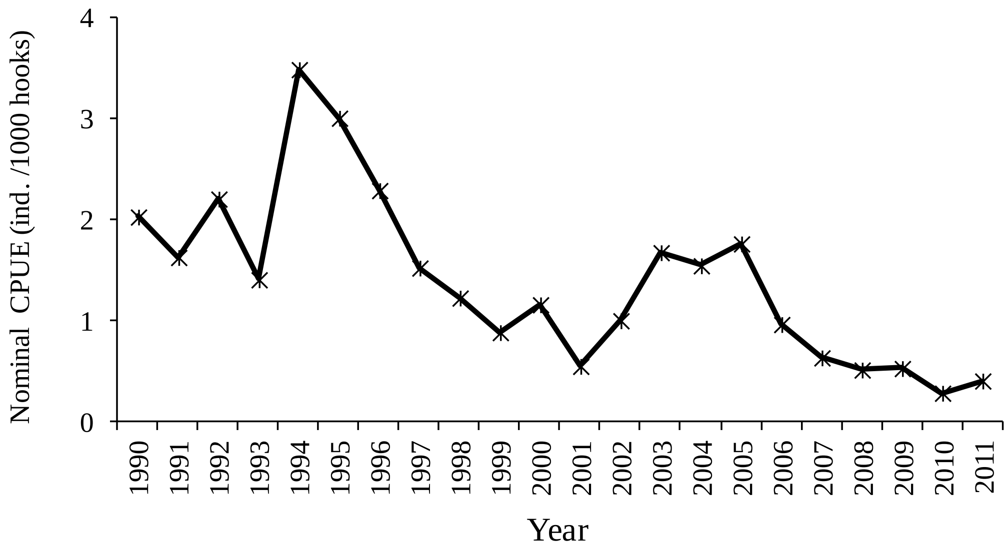
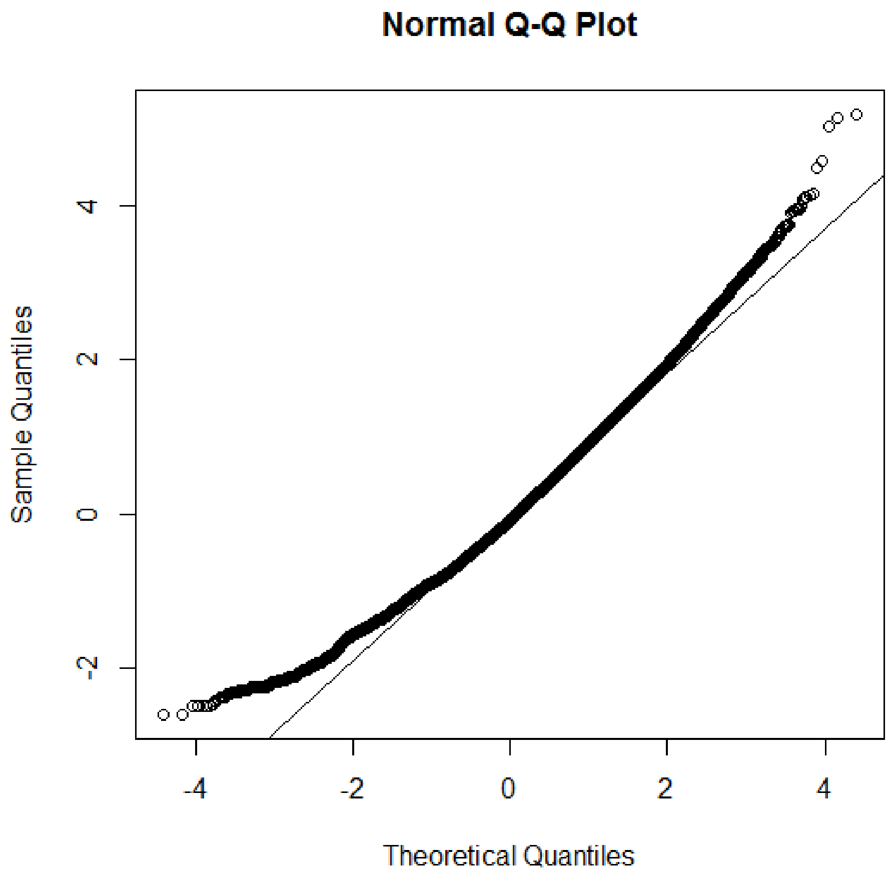


Figure 5. The nominal CPUE trend of yellowfin tuna caught by Taiwanese longline fishery in the tropics of Atlantic Ocean.



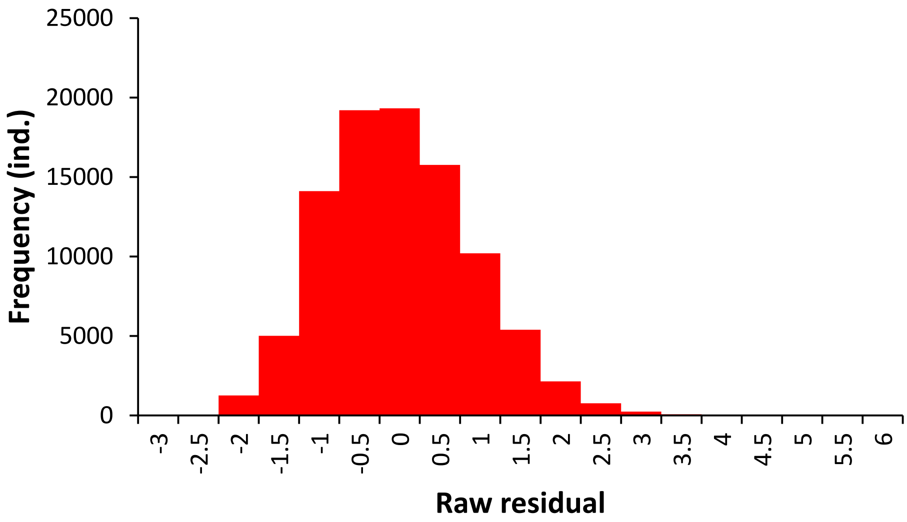
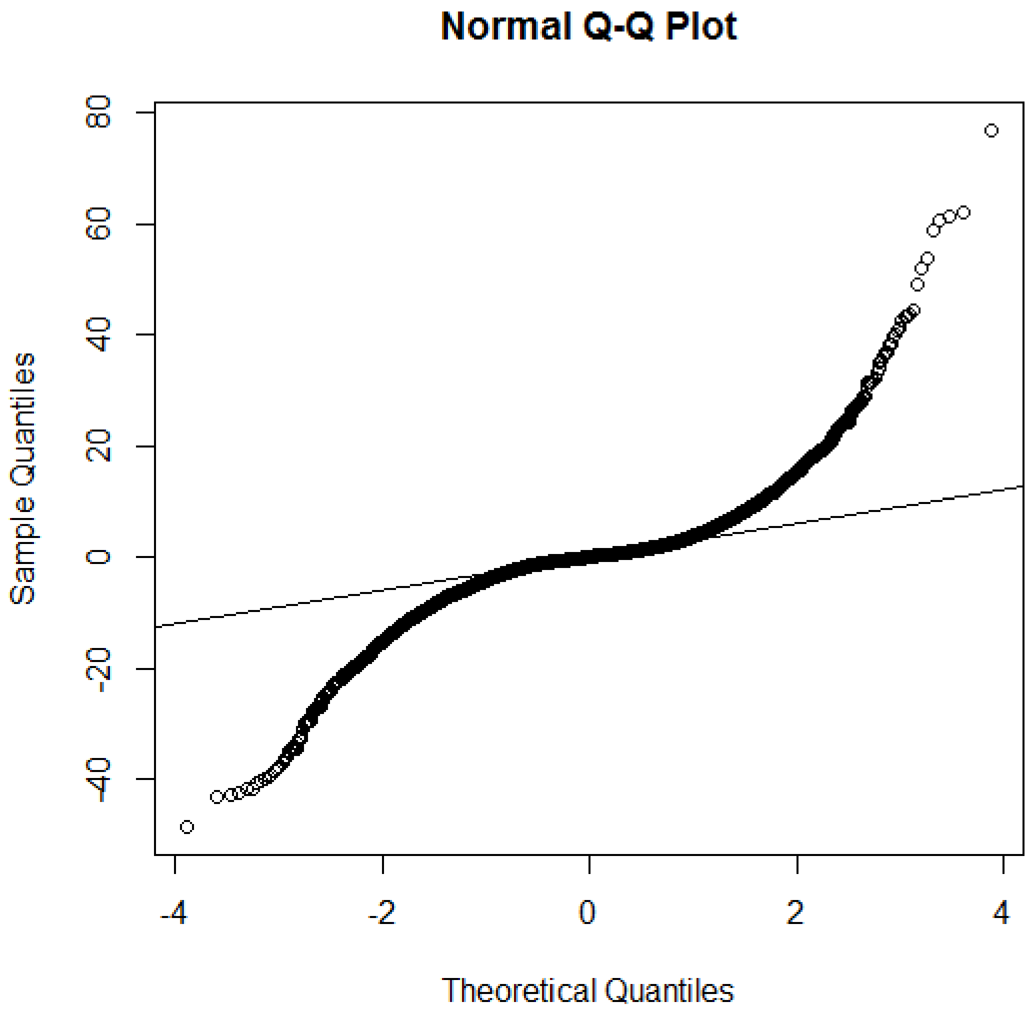


Figure 6. The Q-Q plots (up) and histogram (down) of residuals with lognormal error structure in GLM of positive CPUE for yellowfin tuna caught by Taiwanese longline fishery in the tropics of Atlantic Ocean.



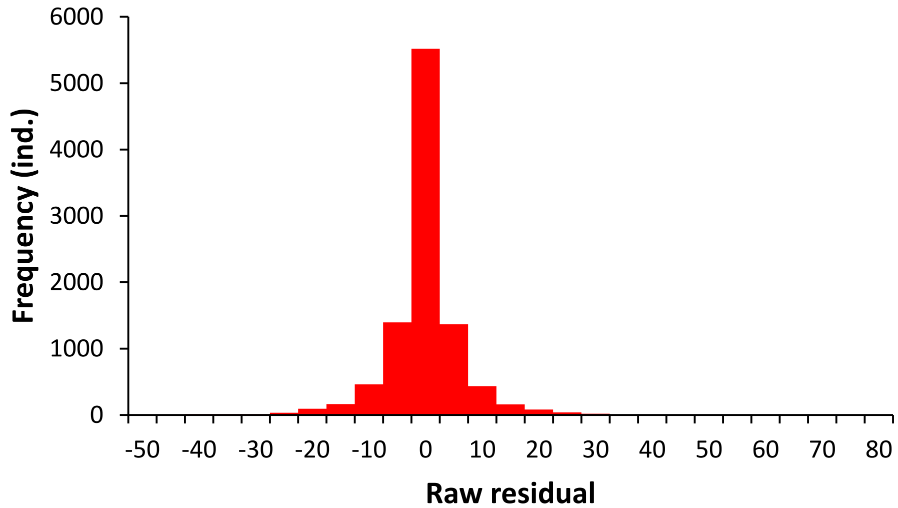


Figure 7. The Q-Q plots (up) and histogram (down) of residuals with binomial error structure in GLM of proportion of positive catch sets for yellowfin tuna caught by Taiwanese longline fishery in the tropics of Atlantic Ocean.

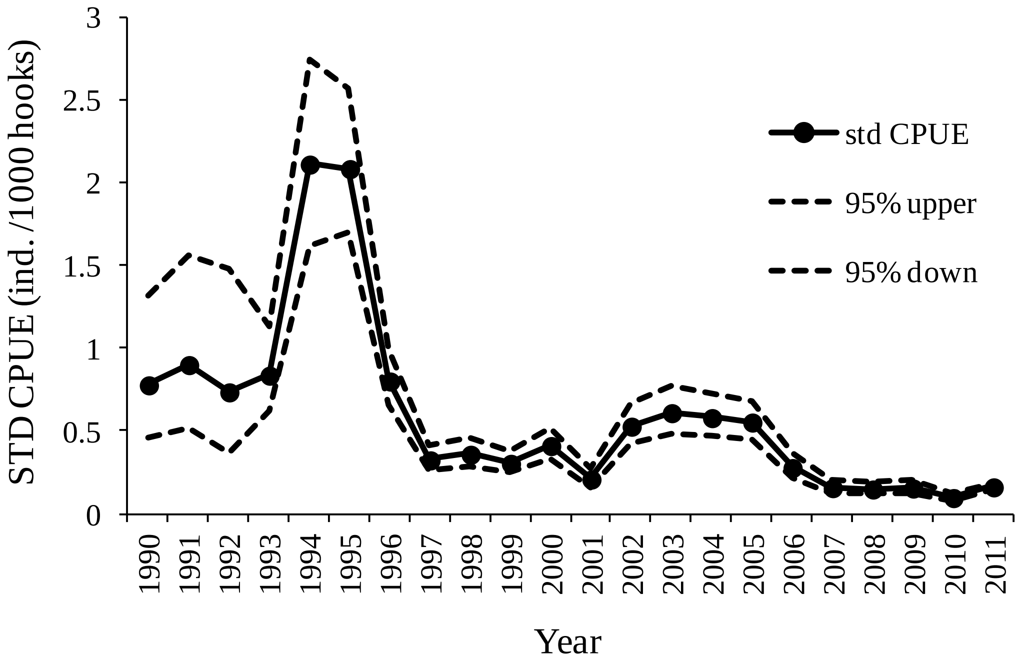


Figure 8. Standardized CPUE of yellowfin tuna caught by Taiwanese longline fishery in the tropics of the Atlantic Ocean.

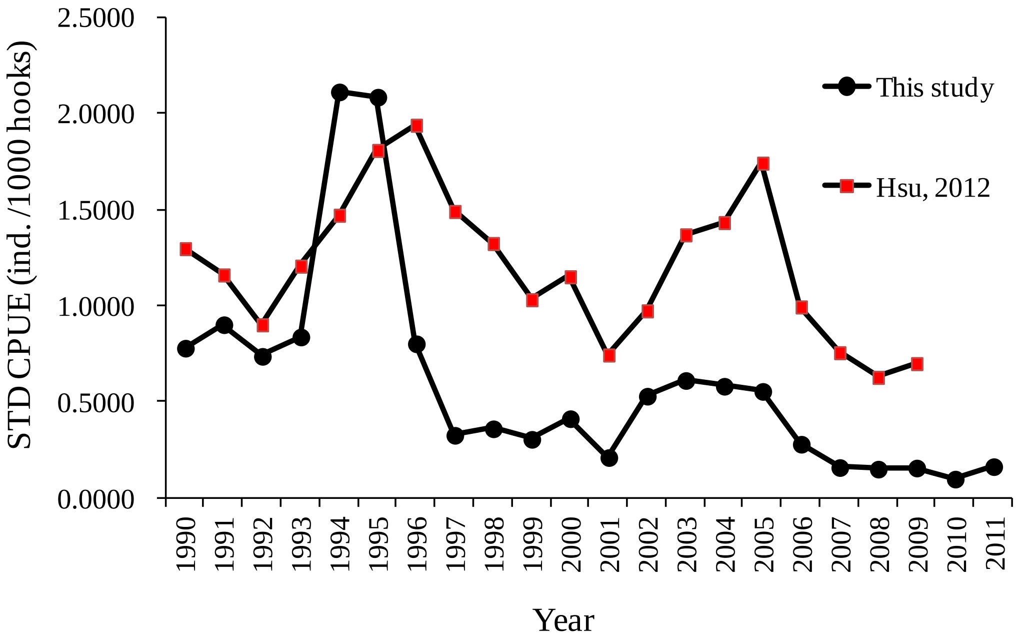


Figure 9. Comparisons of standardized CPUE trends between Hsu (2012) and this study.

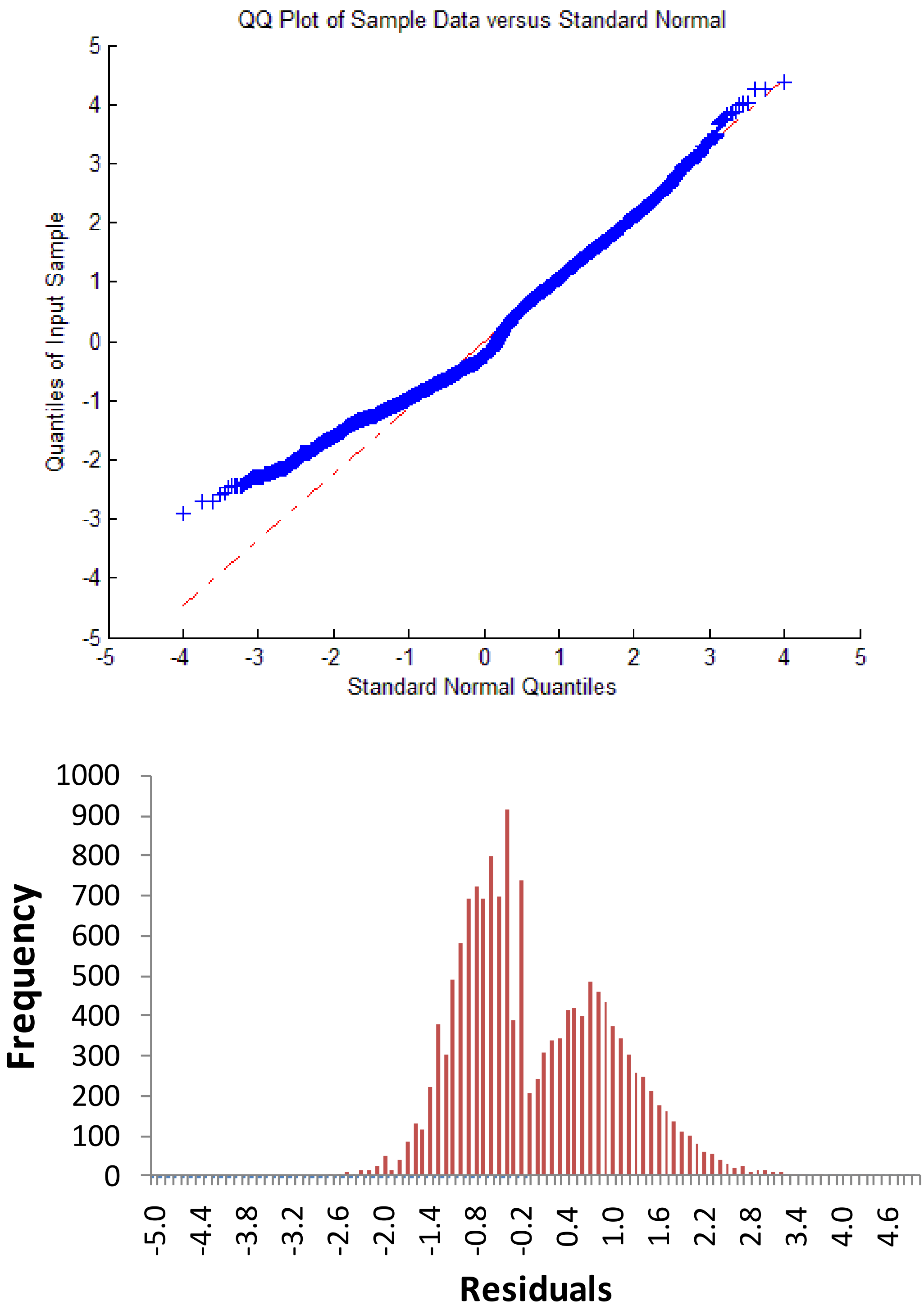
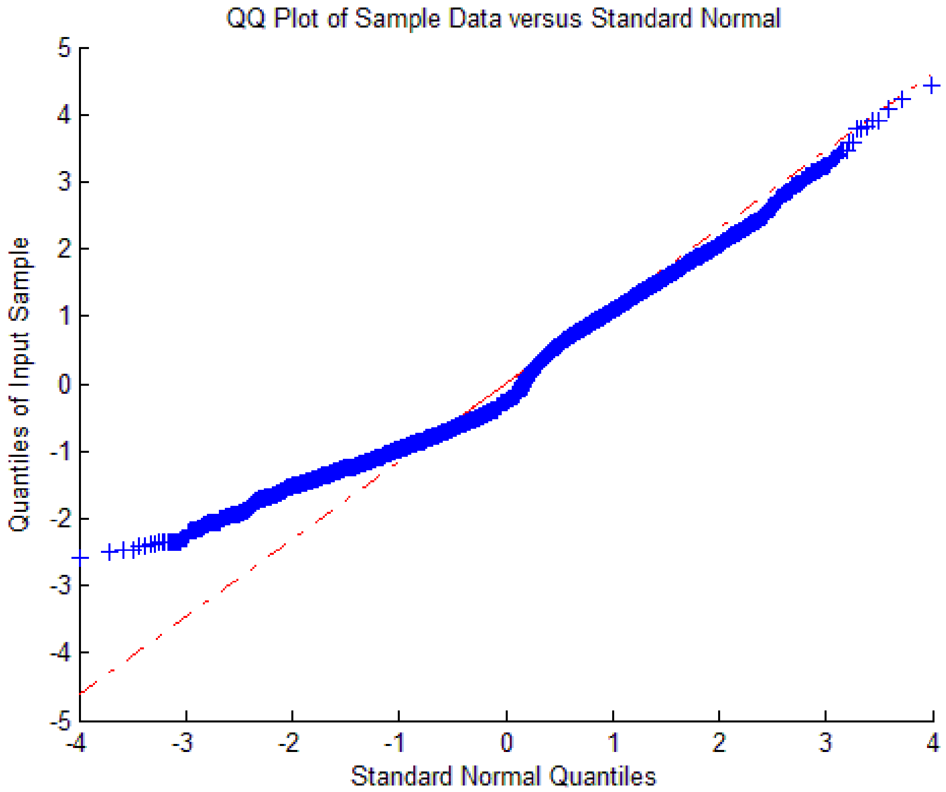


Figure 10. Overall histogram and QQ-plot of standard residuals from the GLM analyses for annual CPUE in number base applying the final model in this study.



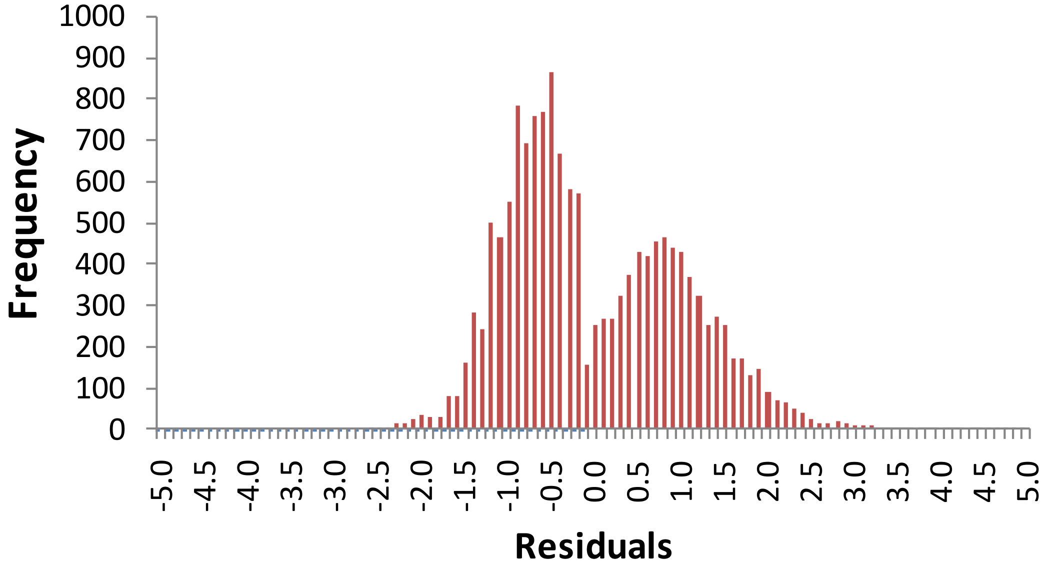
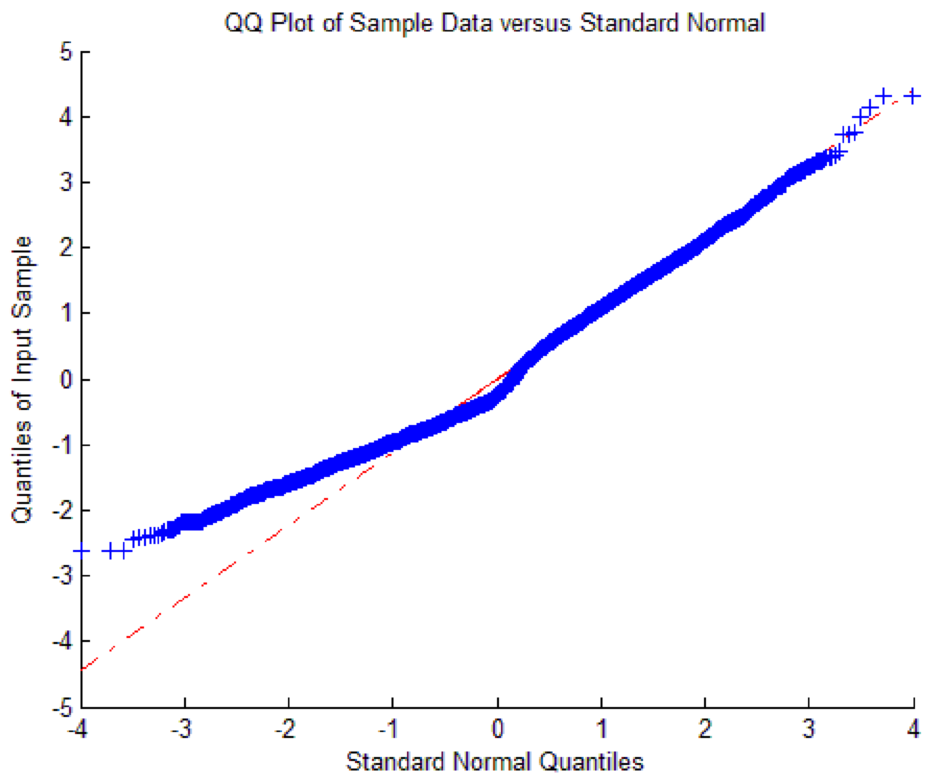


Figure 11. Overall histogram and QQ-plot of standard residuals from the GLM analyses for annual CPUE in weight base applying the final model in this study.



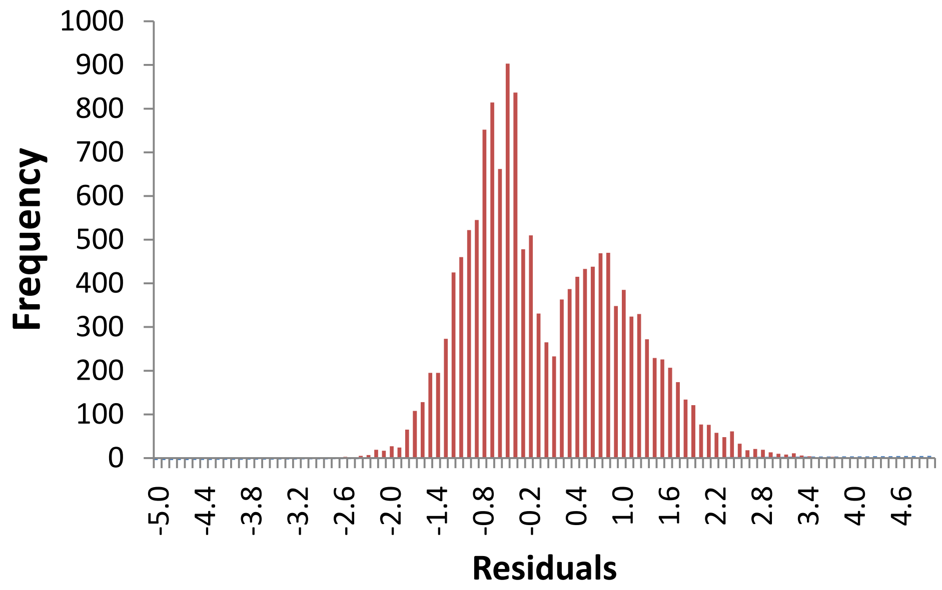
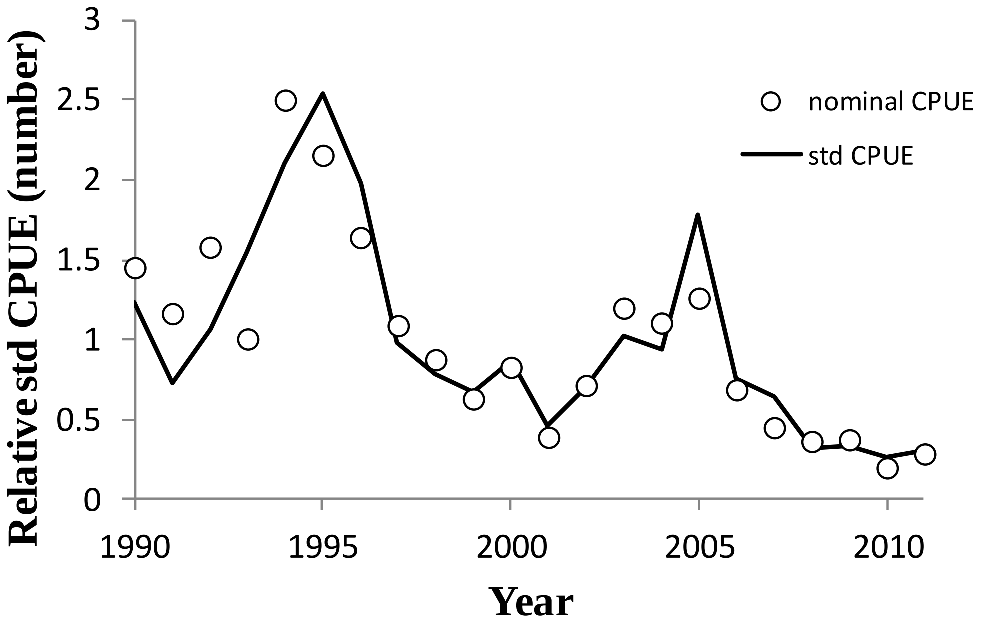
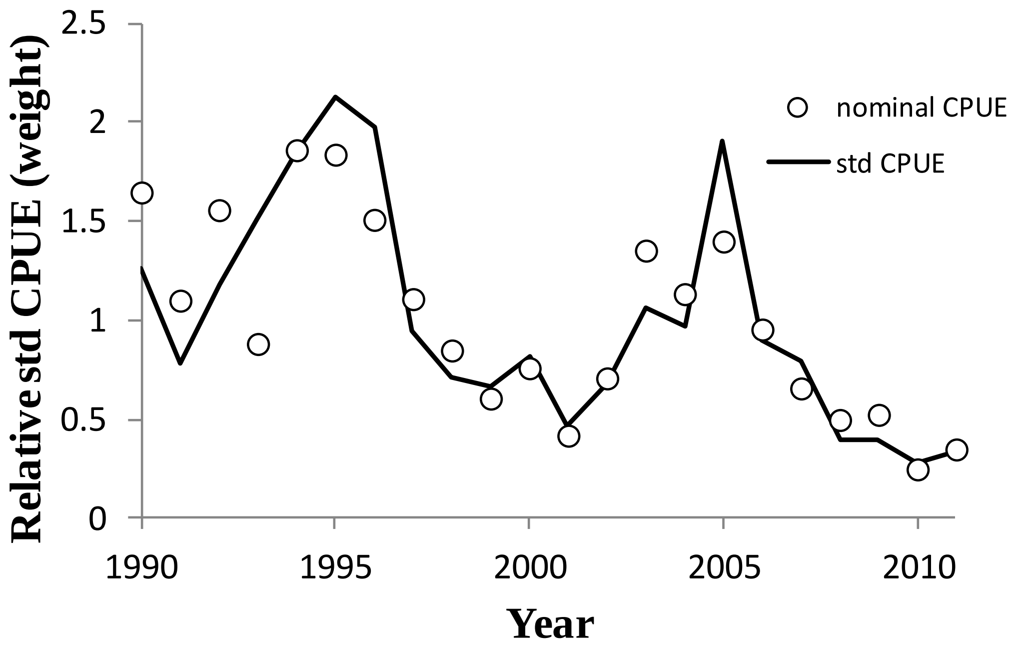


Figure 12. Overall histogram and QQ-plot of standard residuals from the GLM analyses for annual quarter CPUE in number base applying the final model in this study.


3
2.5
2
1.5
1
0.5
0
1990
1995
2000
2005
2010
Relative std CPUE (number)
Year
nominal CPUE
std CPUE


2.5
2
1.5
1
0.5
0
1990
1995
2000
2005
2010
Relative std CPUE (weight)
Year
nominal CPUE
std CPUE

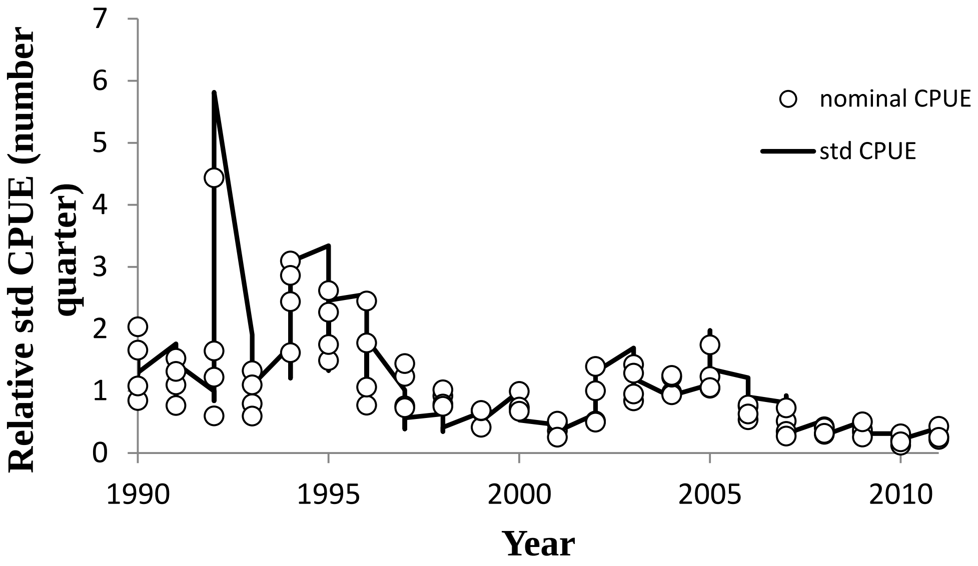


Figure 13. Standardized (solid line) and nominal (open circle) annual CPUE in number (top) , weight (median) and quarter (bottom) base expressed in relative scale in which the average from 1990 to 2011 is 1.0.

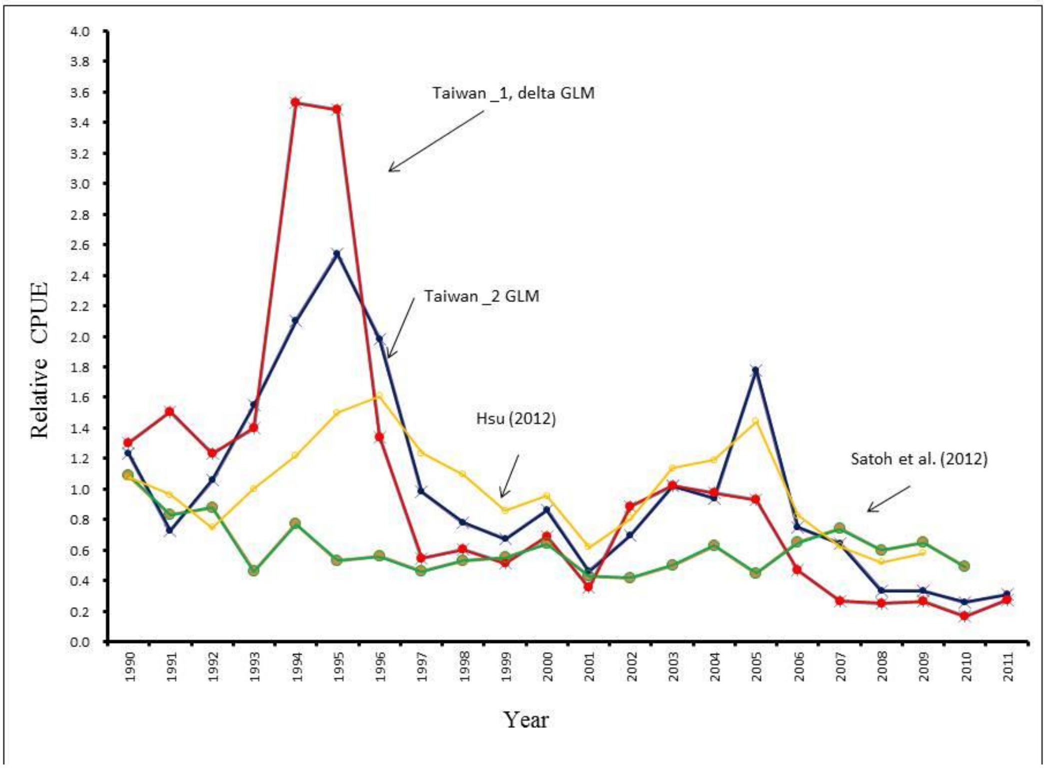


Figure 14. The comparison among different standardized CPUE series of yellowfin tuna by Japanese and Taiwanese longline fleets, in which the values are normalized by average of each series.

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NOTE ON THE YELLOWFIN CATCH AT SIZE BY LONGLINERS AND BY PURSE SEINERS IN THE ATLANTIC AND INDIAN OCEANS

Alain Fonteneau[1] and Emmanuel Chassot[2]

SUMMARY

This note makes a comparison between the yellowfin tuna (YFT) catch at size (CAS) of purse seiners (PS) and of longliners (LL) in the Atlantic and in the Indian Oceans. It shows that when the CAS of pursers and longliners are nearly identical in the Indian Ocean, they are widely different in the Atlantic, with yellowfin caught by purse seine being much larger than for longline-caught yellowfin. These differences may be artificial, for instance, being due to bias in the conversion between predorsal length (LD1) PS samples to fork length CAS, or to insufficient sampling of LL catches. It may also be due to the differential fishing zones of the two gears, PS fisheries being concentrated in the Gulf of Guinea where larger yellowfin are predominant. This heterogeneity in size caught probably corresponds to distinct selectivities at age exerted by these two gears. This differential pattern of selectivities should be better studied and introduced in the stock assessment models that are not stratified by areas, such as virtual population analysis.

RÉSUMÉ

Ce document présente une comparaison entre la prise par taille (CAS) de l'albacore (YFT) des senneurs (PS) et des palangriers (LL) dans les océans Atlantique et Indien. Il montre que les CAS des senneurs et des palangriers sont presque identiques dans l'océan Indien, mais sont très différentes dans l'Atlantique, les albacores capturés à la senne étant beaucoup plus grands que les albacores capturés à la palangre. Ces différences peuvent être artificielles, en raison par exemple du biais de la conversion de la longueur prédorsale (LD1) des échantillons capturés à la senne en CAS de longueur à la fourche ou en raison de l'échantillonnage insuffisant de prises réalisées à la palangre. Ces différences peuvent également s'expliquer par les différentes zones de pêche des deux engins, les pêcheries de senneurs se concentrant dans le golfe de Guinée où les albacores de grande taille sont prédominants. Cette hétérogénéité des tailles des spécimens capturés correspond probablement à diverses sélectivités par âge exercées par ces deux engins. Ce schéma de sélectivité différentiel devrait faire l'objet d'études plus approfondies et être inclus dans les modèles d'évaluation des stocks qui ne sont pas stratifiés par zone, tels que l'analyse de population virtuelle.

RESUMEN

En este documento se realiza una comparación de las capturas por talla (CAS) de rabil (YFT) realizadas por los cerqueros (PS) y los palangreros (LL) en los océanos Atlántico e Índico Demuestra que cuando la CAS de los cerqueros y los palangreros son casi idénticas en el océano Índico, son muy diferentes en el Atlántico, siendo el rabil capturado por los cerqueros mucho más grande que el rabil capturado por los palangreros. Estas diferencias podrían ser artificiales, debiéndose, por ejemplo, al sesgo en la conversión entre la longitud predorsal (LDI) de las muestras del cerco a la CAS en longitud a la horquilla, o a un muestreo insuficiente de las capturas del palangre. También podría deberse a zonas de pesca diferenciadas de los dos artes, estando concentradas las pesquerías de cerco en el golfo de Guinea, donde predominan los rabiles más grandes. Esta heterogeneidad en las tallas capturadas corresponde probablemente a las distintas selectividades por edad que ejercen ambos artes. Este patrón diferencial de selectividades debería estudiarse mejor e introducirse en los modelos de evaluación de stock que no están estratificados por áreas, como los análisis de población virtual.

KEYWORDS

Catch at size, Selectivity, Yellowfin, Fishery statistics

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1. Introduction

Catch at size (CAS) and/or catch at age (estimated from CAS) constitute a fundamental component in all analytical stock assessments such as VPA and ASPM and in statistical models such as MFCL and SS3. This note will compare the average CAS of large YFT taken during recent years by purse seiners (mostly caught on free schools, and mostly obtained from the EU PS CAS sampling) and by longliners in the Atlantic. It will also compare these results to the CAS of large YFT that have been estimated in the Indian Ocean. This comparison will be based on the hypothesis that these CAS are valid ones, and not the result of biased samples or of dubious data processing, but this uncertainty will also be discussed. The observed similarities and differences observed betwee these CAS will be subsequent discussed. The final goal of this comparison is to examine the validity of the frequent hypothesis that the selectivity of adult YFT in the longline fishery and in the free school PS fishery are identical (or similar) and at similar high levels (flat or dome shaped).

2. Average CAS of YFT by PS and LL

Figure 1 shows the average levels of CAS of large YFT caught by each gear caught during the last 20 years. These CAS are based on the size samples submitted by each CPC and they have been extrapolated to the total catches of each gear (a difficult work done each year by the ICCAT & IOTC secretariat).

This figure shows that **in the Atlantic**, the observed patterns of sizes caught by LL & by PS are showing similar larger sizes (about 180 cm) but showing widely different profiles:

- PS CAS of large YFT (free schools) showing a marked mode at 140-150 cm, and much lower catches in the size range of young adults caught between 90 cm and 140 cm.
- LL showing a mode between 120 & 140 cm, followed by a decline of their CAS. Total numbers of adult YFT caught by PS in the size range between 90 & 180 cm) are 2.6 larger than for LL!

On the opposite, the YFT CAS by gear observed in the Indian Ocean are very similar, even nearly identical, for PS and LL in terms of their profiles and absolute levels of CAS (same total CAS of adult YFT). The major difference that can be noticed in the Indian Ocean between these 2 CAS is the larger numbers of very large YFT caught by LL: for instance 2 times more YFT being caught at large sizes over 150 cm by LL than by PS. Data shown by figure 1 are also interestingly shown on figure 2, but now comparing the CAS of each gear in the 2 oceans. This alternate figure shows well how much the CAS by LL are quite similar in the 2 oceans (but with much lower levels of catches in the Atlantic), when on the opposite the average profile of PS CAS of large YFT tend to be widely or totally different in the 2 oceans: showing an average weight of large YFT (>90cm) of 50 kg in the Atlantic, but only 42 kg in the Indian ocean. It is also important to compare the total YFT CAS caught by the combined LL & PS fisheries in the 2 oceans, as this figure shows major differences in the profile of their combined CAS.

This figure shows that the combined CAS of adult YFT caught by LL+PS in the Atlantic and Indian ocean (that are very close to the total CAS of large YFT) are widely different:

- showing a mode at intermediate sizes of large YFT between 115 and 130 cm in the Indian ocean
- showing a mode at much larger sizes between 145 & 165 cm in the Atlantic Ocean, a mode mainly due to PS CAS.

Furthermore and as it is well shown by this figure 3, very large YFT caught at size over 160 cm are frequently caught in the Atlantic (21 % of total adult > 90 cm catches), when they are seldom caught in the Indian ocean (0.6 % of the total catches of adults larger than 90 cm).

3. Discussion

3.1 Overview of the discussion

These marked differences in the YFT PS & LL CAS of large YFT observed in the Atlantic have been seldom analyzed and discussed by ICCAT scientists, but they are important & interesting to discuss as they have potential implications in term of the quality of CAS statistics & of their role in analytical stock assessments. The first point of this discussion will be to examine

(a) if (& how much?) these apparent differences in the YFT Atlantic CAS of PS & LL could be mainly due to large statistical deficiencies & bias in the PS or/and LL CAS, or
(b) if they are real: how they could be explained? And what are their implications in term of stock assessment: what is the real selectivity at size/age of the 2 gears in the Atlantic?
(c) this discussion being also conducted comparing the CAS by gear observed in the Atlantic & in the Indian Ocean.

3.2 Large errors & bias in the PS or/and LL CAS?

The first question is to examine if these apparent differences between PS & LL CAS in the Atlantic are real ones, or due to bias in the size sampling of LL &/or PS.

3.2.1 Size sampling of YFT in the Atlantic LL fisheries

YFT catches by longliners are quite low, an average catch of only 23400 tons during the studied period 1990-2010 (when PS catches of large YFT are reaching 55400tons). Size sampling of these large YFT tunas have been quite limited during this period: an average of 6150 YFT measured yearly for size on longliners, then a quite low number compared to the EU PS showing an average number of about 47 200 large YFT measured each year. Then average sampling rates rate of 280 large YFT sampled per 1000 tons caught each year by LL, vs 850 large YFT sampled yearly per 1000 tons of large YFT landed by the EU PS. An additional point is that these YFT are caught by LL in a very large fishing area, see figure 4a, then in distinct ecosystems, and being caught in widely distinct areas where the YFT sizes are more heterogeneous than in the eastern equatorial area mainly fished by PS. These LL YFT correspond to a combination of catches in feeding strata at temperate latitudes and in spawning strata in warm subequatorial waters. Furthermore, size data are collected by many CPCs, independently and without a consistent homogeneity of the sampling process: size data on longliners have been collected in length or in weight, in straight or round fort length, by 1, 2 or 5 cm size intervals, and the time and area strata of these size samples are also widely heterogeneous (month or quarters, 1°, 5°, 5°-1°, 10°-20° squares (when the EU PS sampling has been always homogeneous in its sampling method and in its time & area strata. The raising process allowing to extrapolate LL samples to their CAS is also much more complex than for PS. This heterogeneity in size sampling of longliners and in their data processing introduces unknown but real uncertainties in the CAS of longline fleets estimated by the ICCAT secretariat.

In such a context of low sampling rate & of large & heterogeneous sampled strata, there is probably a serious uncertainty in the process leading to the extrapolation of size samples, also taking into account the uncertainties in the various strata substitutions that are needed to estimate the CAS, and to the estimated CAS. This basic uncertainty would need to be further studied by an ad hoc statistical analysis of the uncertainties in the estimated CAS of LL.

3.2.2 Size sampling of YFT in the PS fisheries

Thousands of size samples have been collected on large YFT caught by the EU purse seiners during recent years in the Atlantic on free schools. Furthermore, these size samples tend to cover quite well all the major fishing strata, then allowing to estimate a potentially valid CAS with very few strata substitutions. A positive point in this sampling of the EU PS CAS is also that the sampling method and the extrapolation of these samples have been fully consistent over time for the dominant fleet of the EU PS, allowing to consistently estimate PS CAS by 5° and month.

However there is a potentially serious pending (& cryptic….) problem in the CAS of PS submitted to RFO by the EU scientists: when these data have been submitted each year in fork length to ICCAT, all these samples have been measured in predorsal length and later converted in fork length using a fixed statistical conversion between LD1 & Fork length. This average LD1-FL relationship used and the number of YFT sampled in each class of LD1 are shown by figure 5a & 5b. This LD1 size sampling has been used for large YFT (and large BET) by the EU scientists since the late sixties because of 2 additive causes:

(a) the fact that many large YFT frozen in brine (as always for the PS catches) tend to be in bad shape, and often smaller in fork length than the real size of the fresh tunas
(b) the fact that LD1 measurements are more easy and faster to obtain, as they need much less handling to be measured.

However, a subsequent conversion from LD1 size samples to the FL size samples that are submitted to ICCAT (and to IOTC) is needed. This LD1-FL conversion has been done in the Atlantic since the early seventies by the EU scientists based on a sample of LD1-FL measurements that have been done during the early seventies by Caverivière 1976, but unfortunately the original LD1-FL length data of individual tunas leading to this conversion have been lost. The basis of the conversion presently done on a sample of 1975 LD1/FL size samples; based on this sample, each ½ cm class of LD1 (that are used to measure tuna sizes) is converted to the FL size distributions that were observed in this original sampling. As an example 100 YFT sampled at LD1 size between 42 & 42.5 cm will be assigned to the classes of FL shown by table 1. The estimated percentages of FL (by 2 cm class) are estimated for each ½ cm class of LD1 based on an average number of 47 fish that have been measured in each LD1 interval. Based on a new small sample recently done in Abidjan (still unpublished), it would appear that the conversion presently done between LD1 & LF sizes would still be valid and unchanged today, but this LD1-LF sampling would need to be updated and reinforced, well analysed and its results compared to the original results given by Caverivière 1976.

As a conclusion, when the size sampling of large YFT caught by PS appears to be very good in terms of number of tuna sampled and of its spatio temporal coverage, there are still some serious statistical questions that are pending on the validity of the LD1-FL conversion and then in the full validity of the estimated fork length CAS. This basic statistical uncertainty should be fully clarified as soon as possible by EU scientists. The basic recommendation being that a new large scale LD1-FL sample should be conducted by EU & associated scientists of PS caught YFT & BET. This large scale sample should for instance target to sample at least 100 YFT in each class of the 0.5 cm that are routinely used to measure YFT sizes.

3.3 If the differences in PS & LL CAS are real ones: why?

If the major differences in the LL & PS YFT CAS are confirmed to be real ones, these differences would need to be better explained by scientists, and these causes better incorporated in future analytical stock assessments. The differential pattern of CAS observed in the Atlantic between LL & PS (figure 1a) could for instance be easily explained by the different fishing strata of the 2 gears: when PS are mainly fishing in the Gulf of Guinea, longliners tend to fish in a much wider area (figure 4). Their is a clear overlap between the fishing zones of the 2 gears in the area 10°N-5°S, east of 25°W, but longliners are catching a majority of their YFT catches outside the core of this PS fishing zone and this geographical heterogeneity could partly explain the differences in CAS. This is because YFT caught by longliners in temperate areas are on the average showing smaller sizes, see figure 6 An average weight of 60 kg in the Gulf of Guinea (period 1990-2010), vs an average weight of 51 kg in the temperate areas for the YFT caught by LL at sizes over 90 cm (based on the ICCAT sample file).

Figure 6 also shows that the size distribution of YFT caught by LL in the Guinea Gulf, the main fishing zone of PS, are very similar to the PS CAS (much less fish at size under 140 cm and a mode at 152 cm, i. e. at size lower than the PS mode at 154 cm, but close to it (figure 8). It should be kept in mind, when comparing the CAS in the Indian and Atlantic oceans (figure 3) that the differences in the CAS observed in the Indian & Atlantic oceans could easily be explained by the differences in the growth curves of YFT in the 2 oceans: when YFT growth appears to be showing a multistanza pattern in both oceans, the estimated asymptotic sizes appears to be lower in the Indian Ocean: close to 140 cm in the IO and close to 180 cm in the Atlantic (but these 2 results remains somehow questionable….) (figure 7). However, this difference in the growth pattern of YFT in the 2 oceans, real or not, does not condition the main question discussed it this paper: why PS & LL CAS are identical in the IO and widely distinct in the Atlantic.

3.4 Real differences in PS & LL CAS : then what implication for the analytical stock assessments?

If this difference in PS & LL CAS is real in the Atlantic, and this is probably the case, then it should be carefully handled in analytical stock assessments. Most assessments done on the Atlantic YFT tend to assume that the selectivities of PS on free schools and of longliners on adult YFT are maximal and flat for all the adult ages (or showing a similar dome shape pattern). This working hypothesis would be fully valid for the Indian Ocean YFT because of the great similarities of the adult YFT CAS by LL & by PS. However, the widely distinct CAS of these 2 gears that has been repeatedly observed at least during the last 20 years would indicate that the selectivity curve on the adult YFT could be widely distinct for these 2 gears, probably because of geographical heterogeneity in their fishing zones. This question is important, as it tend to condition several of the main results obtained by analytical models, but this work would need additional studies. For instance, all VPAs ran under selectivity patterns of the 2 gears should be consistent with the observed CAS/CAA of large YFT in the LL & PS fisheries. This problem could of course be solved using well stratified geographical stock assessment models such as MFCL, as the geographical heterogeneity in the fished population would explain part/most of the differences in CAS, but these models tend to be quite difficult to handle, and basic VPAs are done without geographical stratification. This question of potential heterogeneity in selectivity patterns for all the assessment analysis done at the scale of the Atlantic should at least be kept in mind and preferably better studied.

4. Conclusion

The marked heterogeneity observed between the average CAS & CAA observed for the adult YFT caught by PS & by LL is clearly surprising and of great interest. Further studies should be done by the EU & other scientists (1) in order to validate the today CAS of PS, (2) to fully understand the cause of their differences and (3) to better evaluate the corresponding heterogeneity in the selectivity of PS & LL at the scale of the entire Atlantic ocean and the potential of this heterogeneity in the future use of the stock assessment models used by ICCAT. This quick analysis of the LL size samples is also leading to a recommendation that these size samples should be more homogeneous and following better ICCAT sampling rules (in terms of size measurements methods and reporting size measurements in homogeneous strata recommended by ICCAT)

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Table 1. example of LD1-FL conversion: LD1 class between 42 & 42.5 cm

FL cm	148	**150**	152	154	156	158	160	162
Numbers	4	**7**	16	23	23	16	7	4

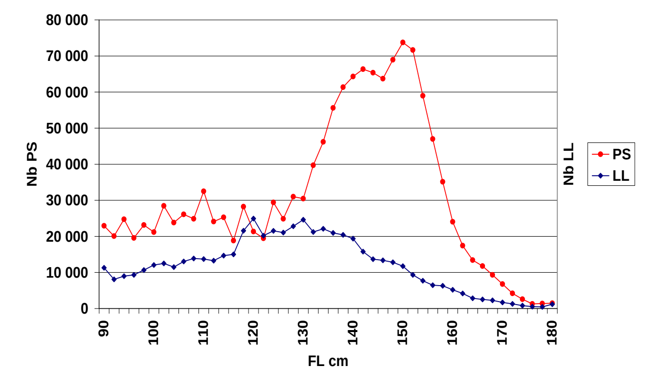

Figure 1 a. Average YFT CAS of PS & of LL in the Atlantic, period 1990-2010

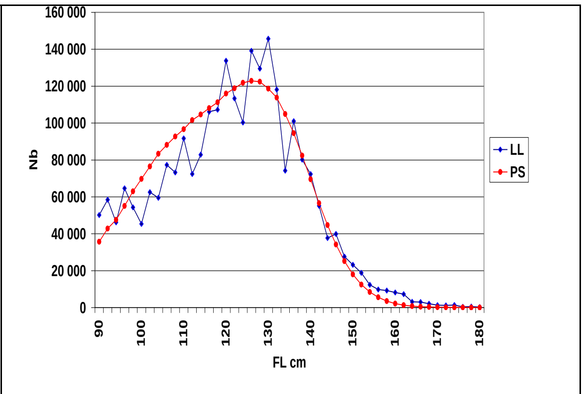

Figure 1 b. Average YFT CAS of PS & of LL in the Indian Ocean, period 1990-2010

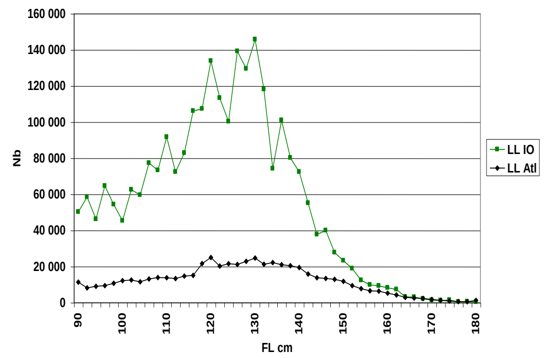

Figure 2a: Average CAS of LL in the 2 oceans

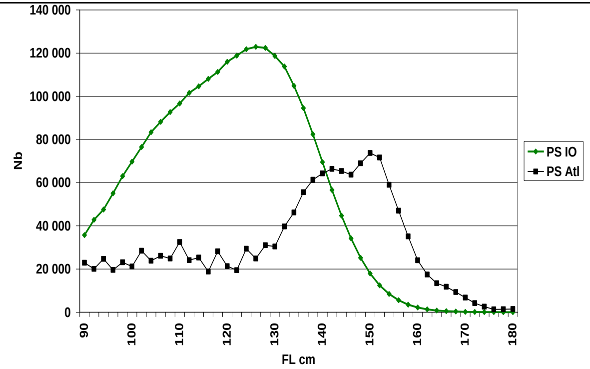

Figure 2b: Average CAS of PS in the 2 oceans

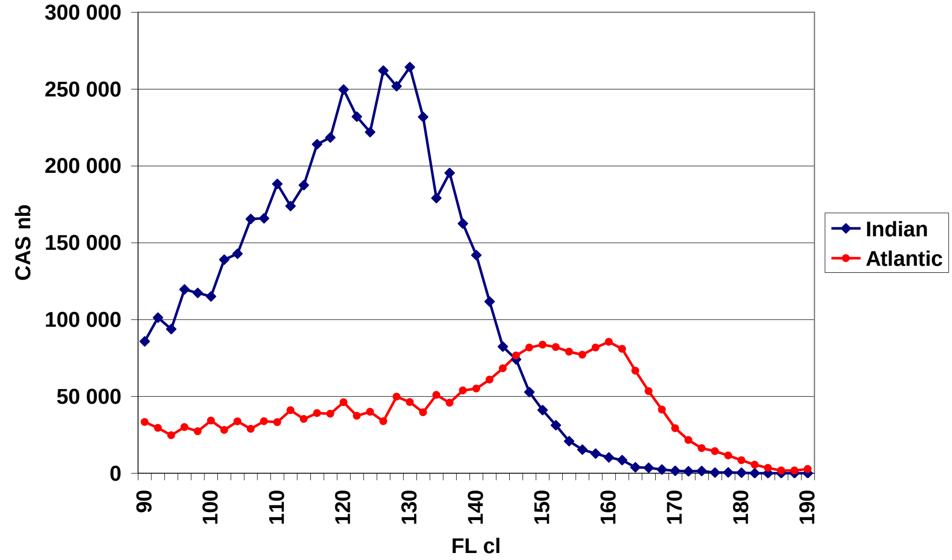

Figure 3. Total YFT CAS caught by the combined LL & PS in the Atlantic & Indian oceans

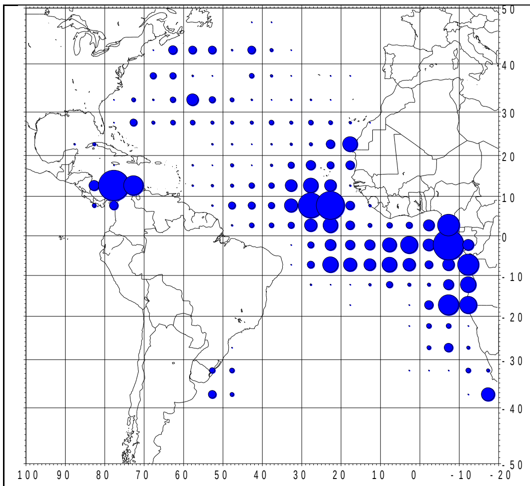

Figure 4a. Average catches of YFT caught by 5°squares of longliners during the 1990-2010 period

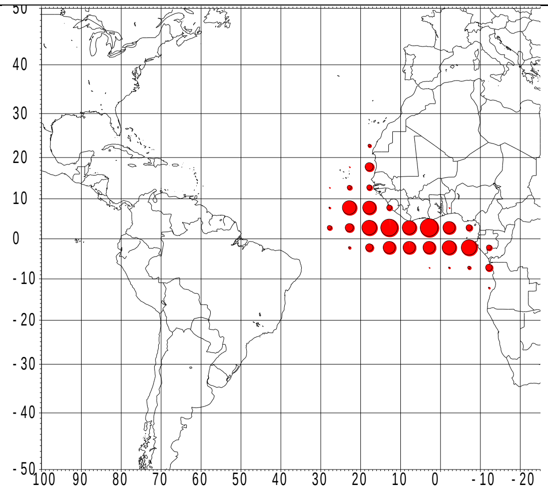

Figure 4b. Average catches of YFT caught by 5°squares of purse seiners during the 1990-2010 period

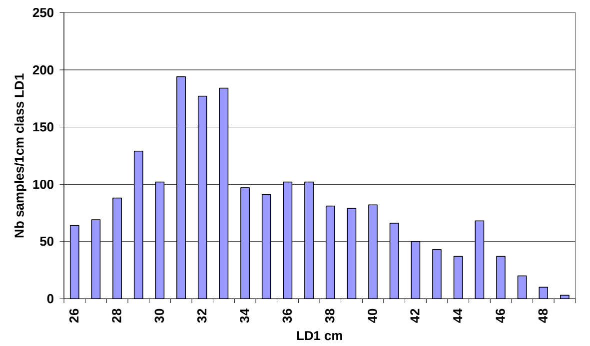

Figure 5a. Number of YFT sampled for LD1-FL in each 1cm class of LD1 in the Caverivière 1976 sample.

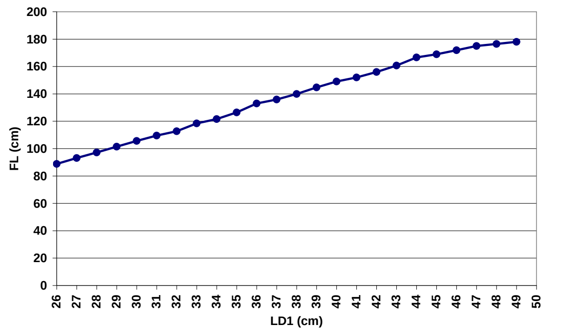

Figure 5b. Average relationship used to converts LD1 samples to FL CAS (based on the Caverivière 1976 sample)

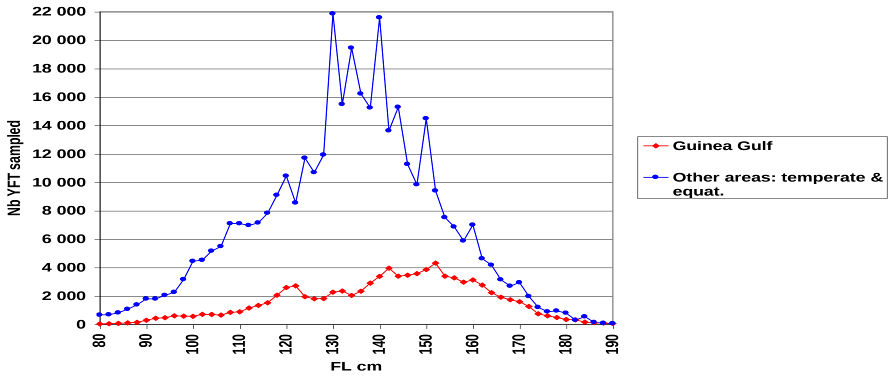

Figure 6. Average size distribution of YFT caught by LL in the 10°N-10°S area east of 20°W, and in the other areas of the Atlantic ocean, mainly temperate ones (period 1990-2010). Average weight Guinea Gulf=60kg (red), and 51 kg for the other areas (blue)

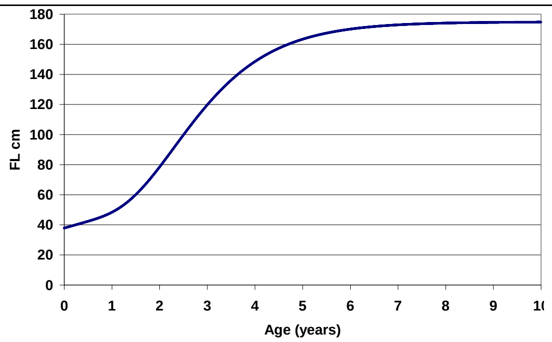

Figure 7a. Growth curve of YFT estimated in the Indian Ocean (Dortel 2011)

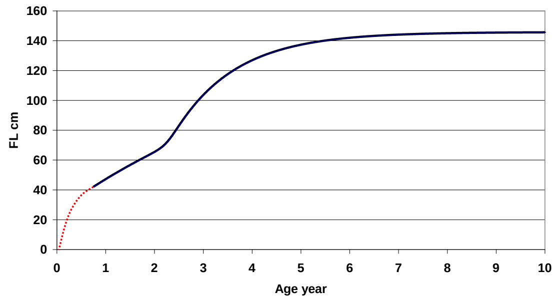

Figure 7b. Growth curve of YFT estimated in the Indian Ocean (Gascuel et al 1992)

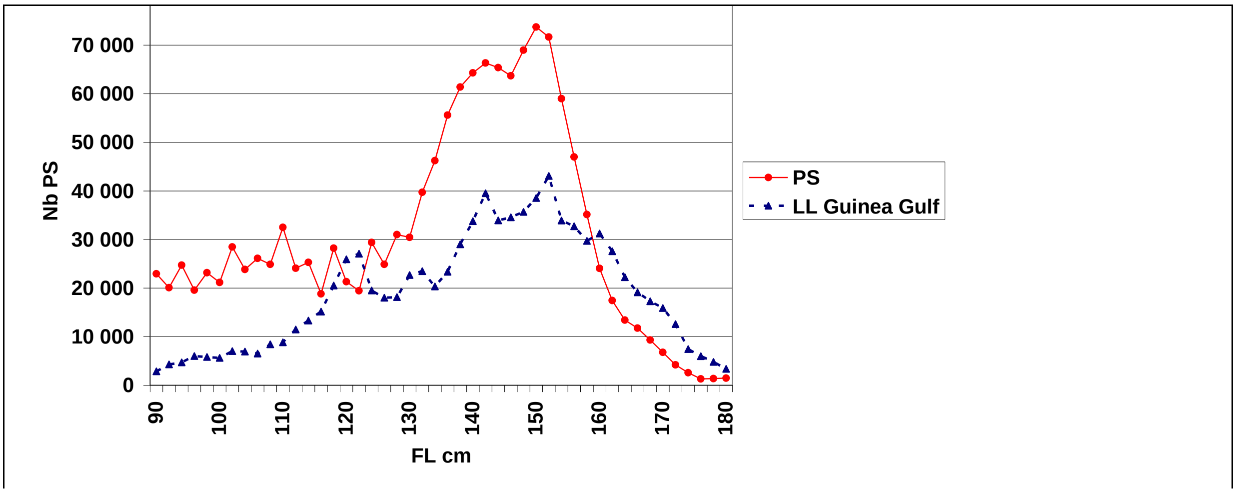

Figure 8. Average size distribution of YFT caught by LL in the 10°N-10°S area east of 20°W (cumulated samples) and PS CAS of large YFT (mainly caught in the same area)

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ANALYSIS OF THE SPANISH TROPICAL PURSE-SEINE FLEET'S EXPLOITATION OF A CONCENTRATION OF SKIPJACK (*KATSUWONUS PELAMIS*) IN THE MAURITANIA ZONE IN 2012

Alicia Delgado de Molina,[1] Vanessa Rojo,[2] Eugenio Fraile-Nuez[1] and Javier Ariz[1]

SUMMARY

From August to November 2012, an important concentration of skipjack occurred in the Mauritania zone. This situation was exploited by the Spanish purse-seine fleet, which obtained significant yields over floating objects. We analyze the characteristics and some of the possible causes of this concentration.

RÉSUMÉ

Entre le mois d'août et le mois de novembre 2012, une importante concentration de listaos s'est formée dans la zone mauritanienne. Cette situation a été exploitée par la flottille espagnole de senneurs qui a obtenu des prises importantes avec des objets flottants. Nous analysons les caractéristiques et quelques-unes des causes éventuelles de cette concentration.

RESUMEN

Entre agosto y noviembre de 2012 se produjo una importante concentración de listado en la zona de Mauritania, circunstancia que aprovechó la flota de cerco española para obtener importantes rendimientos con pescas sobre objetos flotantes. Se analizan las características de esta concentración y algunas de sus posibles causas.

KEYWORDS

Skipjack, Tropical purse-seine fishery, Catch/effort, Environmental parameters

1. Introduction

In August, September, October and November 2012, the Spanish tropical purse-seine fleet focused a considerable part of its fishing effort on artificial floating objects in waters close to Mauritania, an uncommon area for this period of the year and for this fishing mode, with extraordinary yields of skipjack.

This document analyzes the characteristics and some of the possible causes of this concentration.

2. Material and methods

We analyzed data from the fishing activity of the Spanish fleet and associate by comparing the characteristics of the sets and yields in the zone examined (between 15ºN and 20ºN) and the rest of the fishing zone, from August to November 2012.

The baseline data for this paper are taken from fishing logbooks, from samplings carried out at the landing ports to obtain composition per species and size distributions of the catch, and from the landing data. Since the 1984 meeting of the Working Group on Tropical Tuna, specific catch composition has been corrected from the data resulting from multi-species sampling and according to the procedure outlined by the group (Anon, 1984). Since 1991, changes in the fishery after the introduction of fishing over floating objects with buoys entailed the revision of error-correcting procedures for specific composition and size distribution, due to important differences in the characteristics of catches obtained over objects or free schools. In 1996 and 1997, a

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coordinated programme (France-Spain-European Union) was developed to analyze the tropical tuna sampling and data processing strategy. Accordingly, a suitable sampling scheme (Pallarés, P. & Ch. Petit, 1997) was devised from a statistical perspective to correct specific composition and to obtain catch size distributions.

Daily high-resolution Sea Surface Temperature (SST) time series are taken from the NOAA-THREDDS Data Server (NOAA-THREDDS, 2012), As Reynolds et al. (2007) reported, these SST time series are obtained by an optimum interpolation method that uses Advanced Very High Resolution Radiometer (AVHRR) infrared satellite SST data, in combination with in situ surface data from ships and buoys. They include a large-scale adjustment of satellite biases with respect to the in situ data. The analyses have a spatial grid resolution of 0.25°. SST monthly average maps show the differences temperatures anomalies in the months analyzed in 2012 and the corresponding months of the previous three years (2009-2011).

3. Results and discussion

Figure 1 shows a map of catches, per species, over floating objects, by the Spanish fleet in the Atlantic Ocean, in 2012. **Figure 2** gives the same information, considering the average catches for 2007-2011. A comparison of both figures reveals that in 2012 there was a high concentration of mostly skipjack, in latitudes above 15ºN and in an area very close to the coast, while in 2007-2011, this same area was virtually barren.

Another of the characteristics observed is the time of year when the concentration occurred. **Figure 3** shows that few catches were obtained in the Mauritania zone from August onwards.

The question that emerges from this figure is why boats went to that unfrequented area at that time.

According to information provided by skippers, several coincidental circumstances led the fleet to that area. On the one hand, that year the fleet did not set sail for Gabon, which would have been normal practice, as there was no fishing agreement in force with that country. On the other hand, Dakar bait boats' frequent entries into port alerted them of the possibility of high productivity in the area. In April and May, several vessels seeded objects in the Guinea Conakry and Guinea Bissau zones, which were recovered in the area and period analyzed. Moreover, according to information provided by the fleet, the objects deposited in the area were highly productive and concentrated significant amounts of fish in a very short time (10 or 15 days).

The left column of **Figures 4, 5, 6** and **7** shows the catches, in tons, made over floating objects during the months analyzed, while the right column gives the fishing effort, in fishing days, corresponding to those months. We see that in August and September, despite important effort values throughout the fishing area, yields are only significant in the Mauritania zone. In October catches in the Mauritania zone are still important but are now observed in other zones. By November, although there continue to be catches over objects in the Mauritania zone, they are lower than those of the previous three months.

Figure 8 shows the number of purse-seiners inside and outside the area in question per month and for all four months, in order to analyze yields both inside and outside the area.

We now compare the Mauritania zone in 2012 with previous years. **Figure 9** shows the total number of sets per month (August, September, October and November) in 2012 and the average for those months from 2000 to 2011, confirming what is shown in **Figure 3** (namely that the fleet is rarely present in this area at that time of the year), and the information about the catches (**Figure 10**).

Figure 11 presents the catch, per species for all four months and areas considered, separating catches made over objects and over free schools. Catches over free schools are minimum in comparison with those obtained over floating objects, skipjack being the dominant species (**Figures 10 and 11**).

In order to track the evolution of skipjack catches over the four months, **Figure 12** shows the catch, per month, for this species, over object and free school, September being the month with the highest catches.

Figure 13 gives the daily catch-per-unit-of-fishing-effort (CPUE) in tons per fishing day for the four months considered. September shows the highest yields, with up to 61 t in one day. **Figure 14** gives the monthly CPUE, which varies between 31.8 t per fishing day for September and 11 t per fishing day for November.

These yields are exceptionally high if we compare them with the annual yields of the Spanish fishery given in **Table 1**. For the period 1991 to 2012, yields are much lower, in the order of 5 t per fishing day, an average of 7 t per fishing day for that period.

Figure 15 gives the distribution per size and month for the period and area considered, while **Figures 16** and **17** compare size and weight distributions, respectively, inside and outside the Mauritania zone. The area analyzed reveals a significant rate of larger and heavier specimens than the rest.

Figures 18, 19, 20 and **21** show the differences in surface temperatures when comparing 2012 with 2009 (left), 2010 (centre) and 2011 (right), for August (**Figure 16**), September (**Figure 17**), October (**Figure 18**) and November (**Figure 19**). In the four months analyzed, we observe that 2011 was a much colder year than 2012, with a difference of three degrees in many cases. For the three years compared, September 2012 had the highest temperature. In general, 2012 had higher temperatures in this area and in these months, when compared with the three previous years.

This type of specific concentrations is not new. There are many examples in the history of the tropical tuna purse-seine fishery (Fonteneau, 1986; Fonteneau, 1991, Ménard et al. 1998, Ravier et al. 2000), with numerous references to skipjack, affecting the abundance (large concentrations in time and space strata) and the catchability of the species (intense exploitation).

The CPUE will be affected not only by the abundance of the resource but also by environmental variables (which facilitate the concentrations) and by the fishing strategy (Andrade et al, 2005).

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Table 1. CPUE (tons/fishing days) of skipjack for the Spanish purse-seine fleet in the East Atlantic.

YEAR	*SKJ*
1991	8.66
1992	4.93
1993	6.82
1994	5.56
1995	6.44
1996	4.96
1997	5.47
1998	4.82
1999	6.83
2000	6.64
2001	5.74
2002	4.63
2003	9.18
2004	8.15
2005	7
2006	6.71
2007	6.33
2008	7.47
2009	6.42
2010	7.84
2011	10.79
2012	13.23

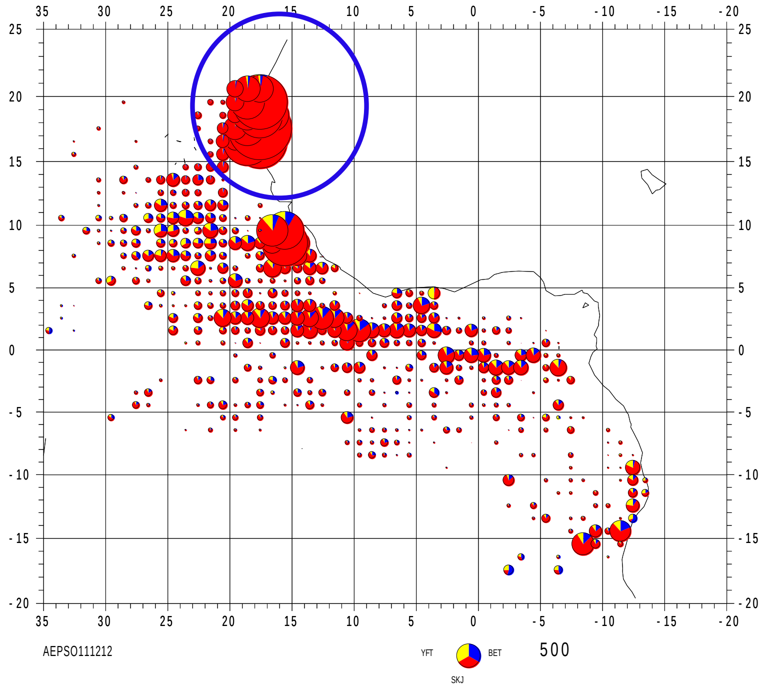


Figure 1. Distribution of bigeye, skipjack and yellowfin catches over **floating objects** of the Spanish tuna purse-seine fleet in 2012.

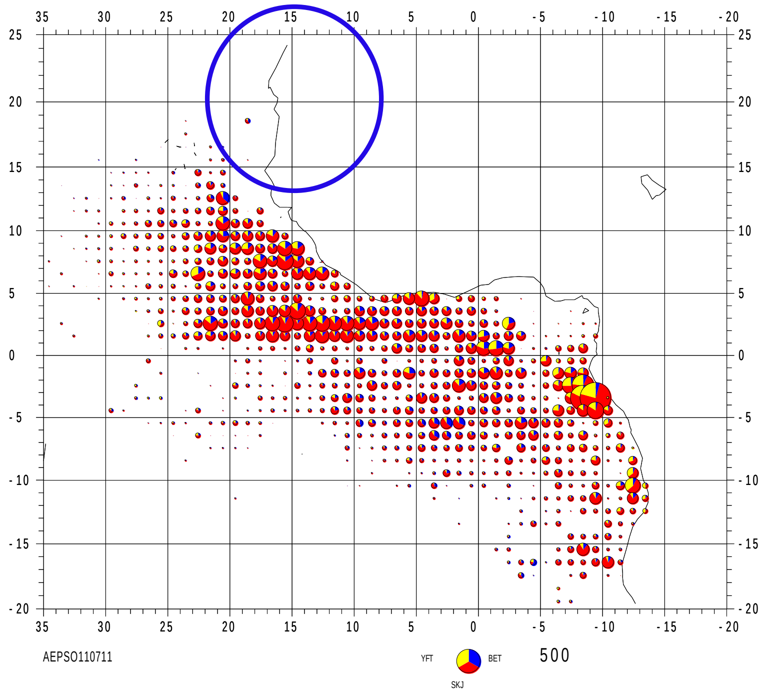


Figure 2. Average distribution of bigeye, skipjack and yellowfin catches over **floating objects** of the Spanish tuna purse-seine fleet for 2007-2011.

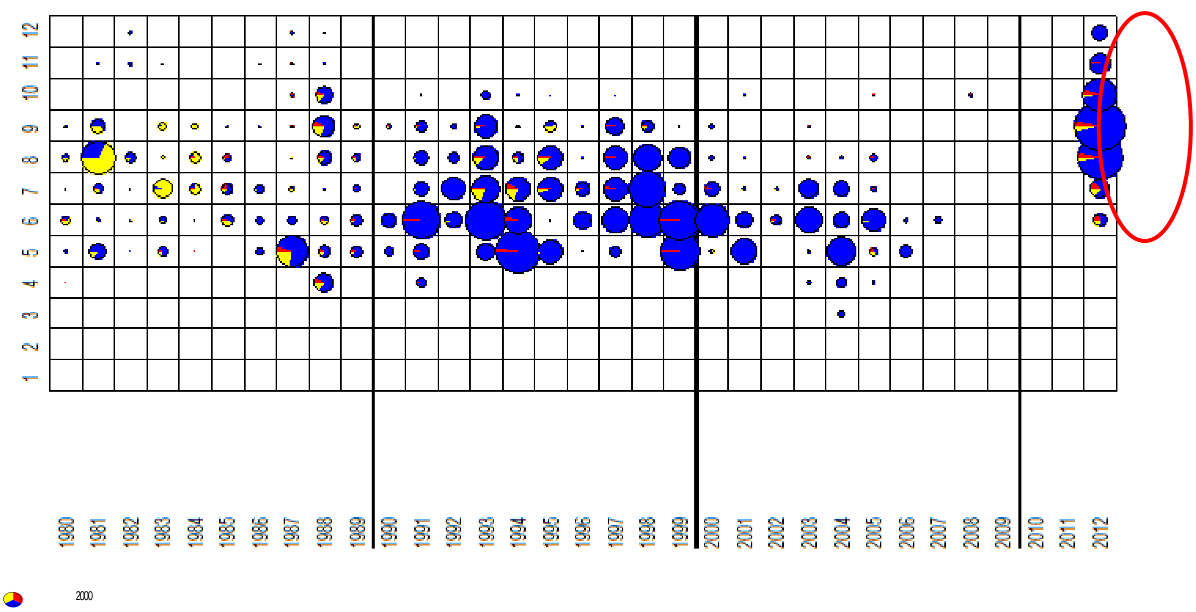
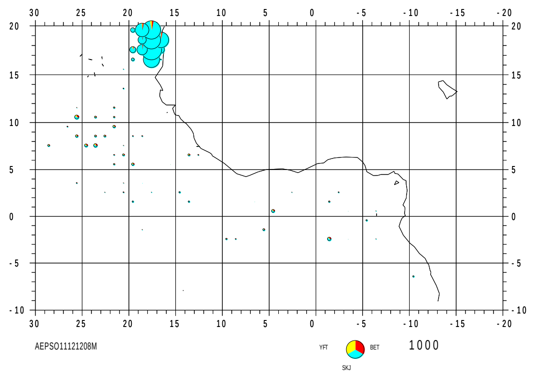


Figure 3. Monthly catches for the European purse-seine fleet in the Mauritania zone (>15ºN) for 1980-2012.



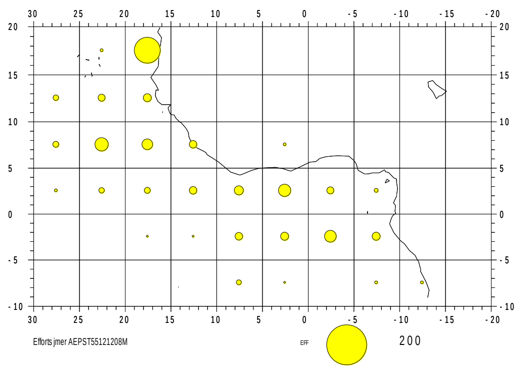


Figure 4. Distribution of catches (left) over **floating objects** and fishing effort (right) of the Spanish tuna purse-seine fleet in **August** 2012.

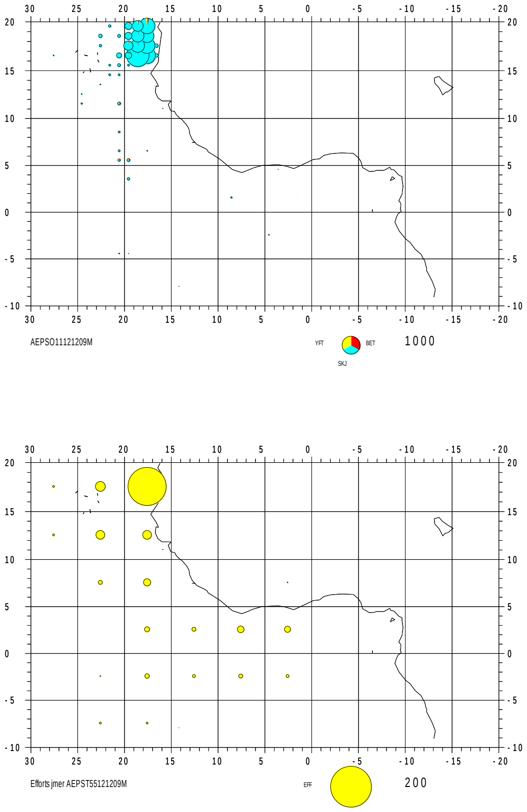
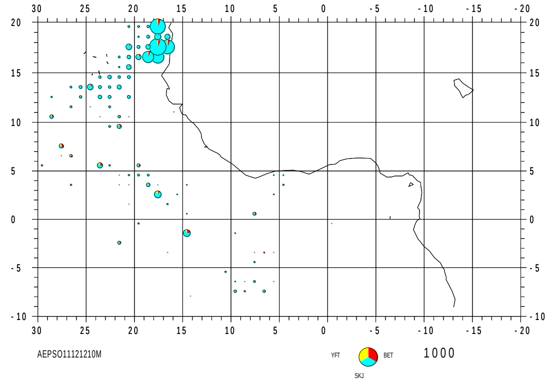


Figure 5. Distribution of catches (left) over **floating objects** and fishing effort (right) of the Spanish tuna purse-seine fleet in **September** 2012.



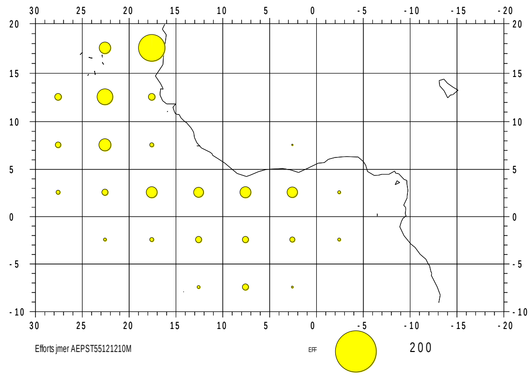


Figure 6. Distribution of catches (left) over **floating objects** and fishing effort (right) of the Spanish tuna purse-seine fleet in **October** 2012.

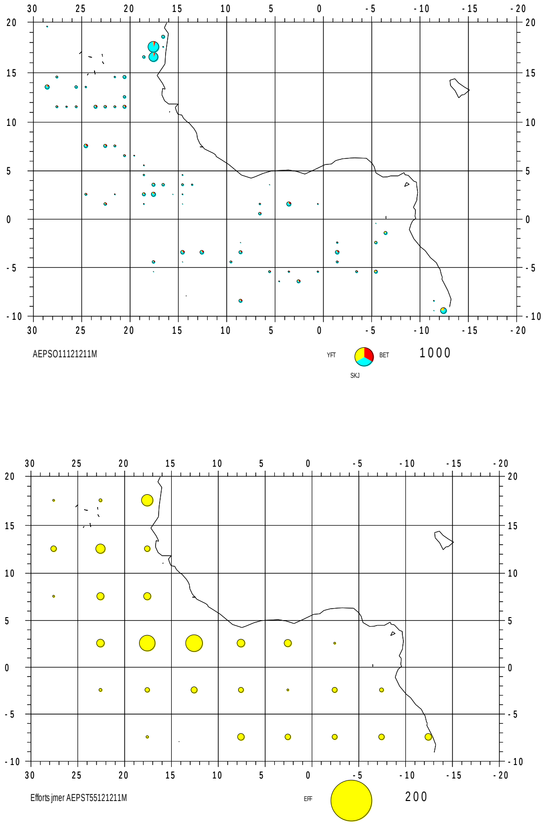


Figure 7. Distribution of catches (left) over **floating objects** and fishing effort (right) of the Spanish tuna purse-seine fleet in **November** 2012.

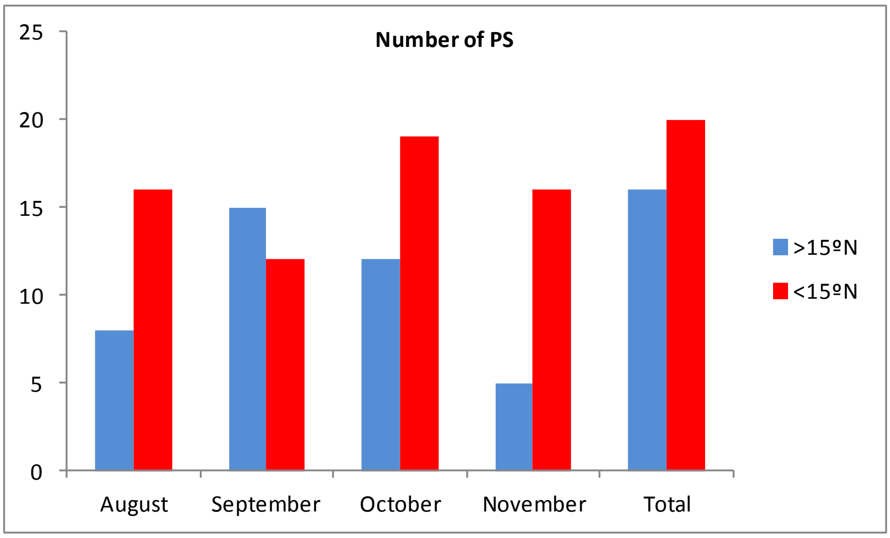


Figure 8. Number of purse-seiners in the Spanish fleet and associates inside and outside the area considered, per month and in total.

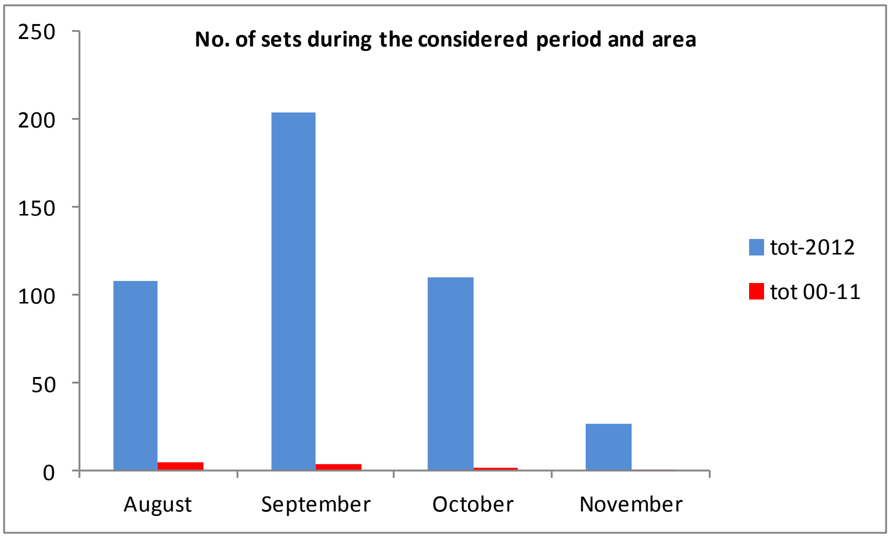


Figure 9. Total number of sets in the months and area considered for 2012 and average number, in the same area, for 2000-2011.

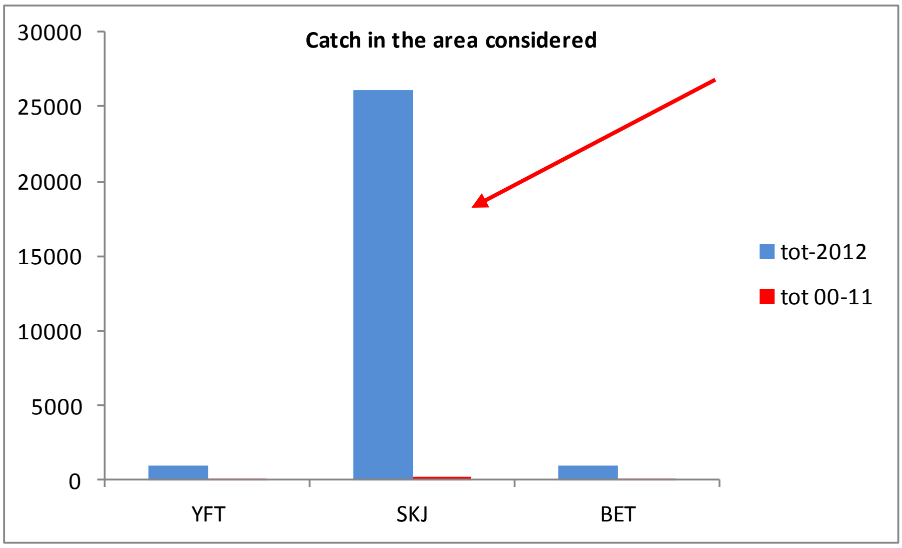


Figure 10. Catch, per species, in the months and area considered for 2012 and average number, in the same area, for 2000-2011.

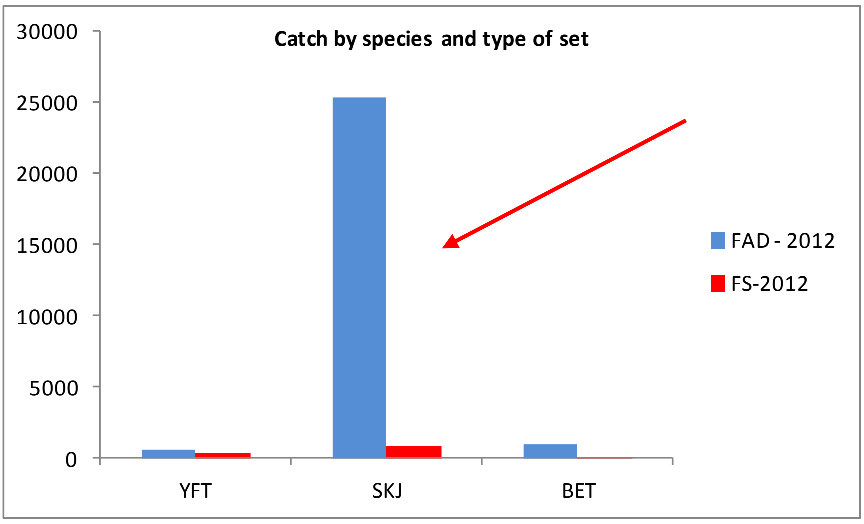


Figure 11. Catch, per species, in the months and area considered for 2012, according to fishing mode.

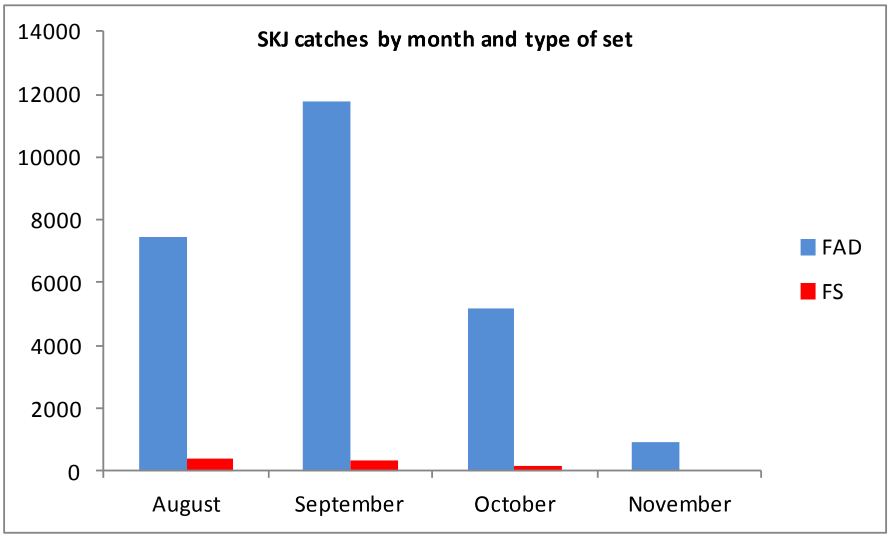


Figure 12. Skipjack catch in the months and area considered for 2012, according to fishing mode.

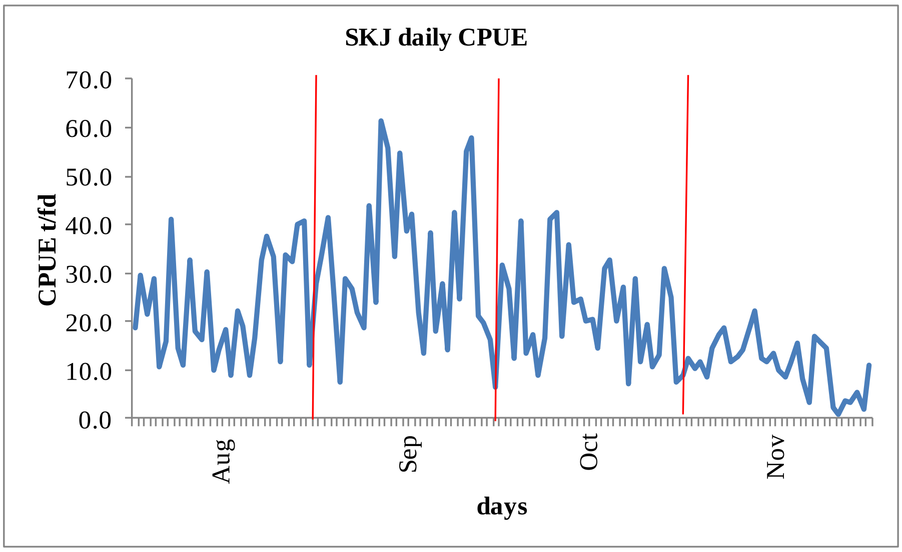


Figure 13. Daily catches per CPUE (tons/fishing days) for the Spanish purse-seine fleet and associates in the zone and period analyzed.

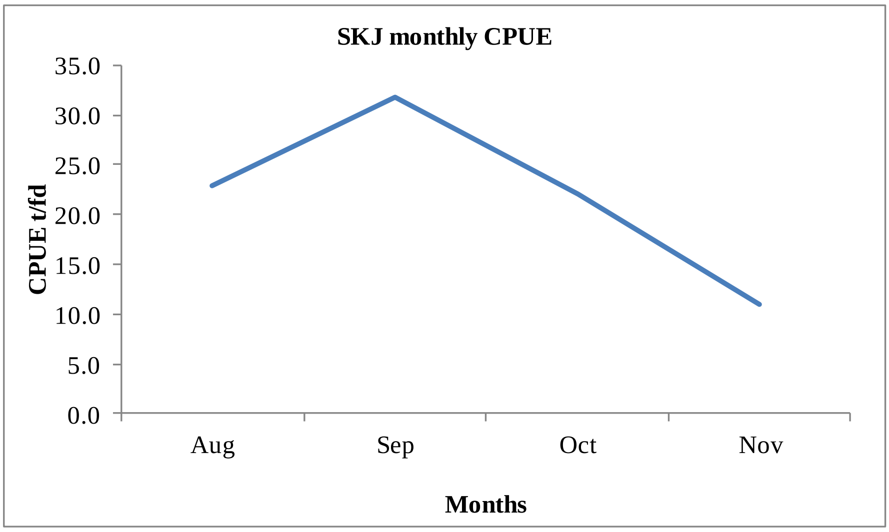


Figure 14. Monthly catches per CPUE (tons/fishing days) for the Spanish purse-seine fleet and associates in the zone and period analyzed.

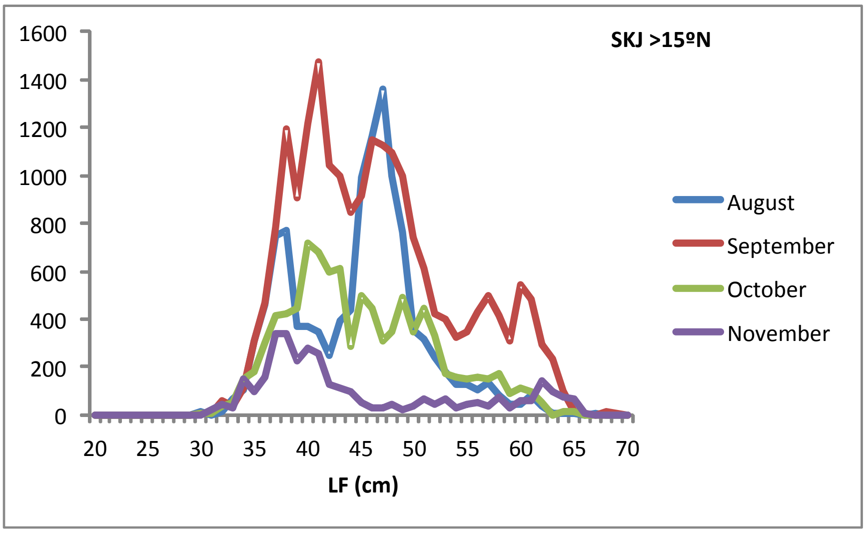


Figure 15. Distribution of sizes, per month, over floating objects, in the period and area considered for 2012.

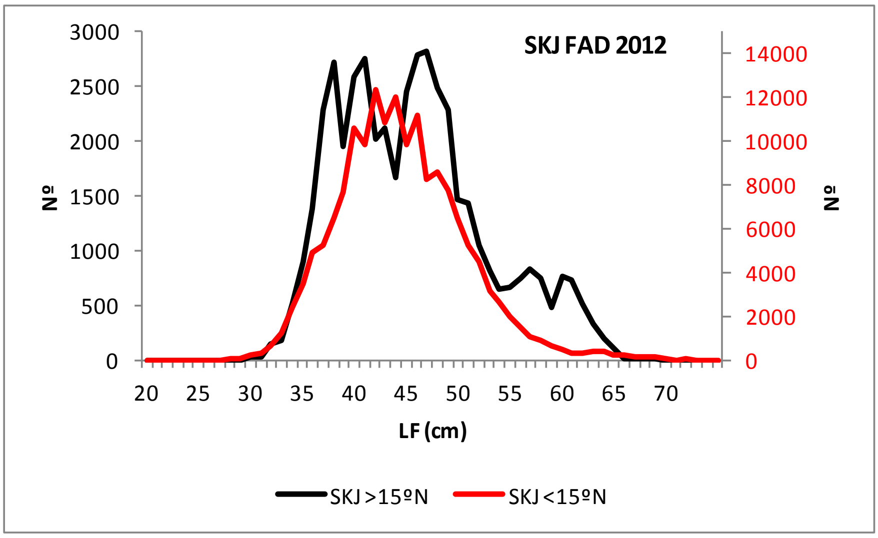


Figure 16. Distribution of sizes over floating objects, inside and outside the area and period considered for 2012.

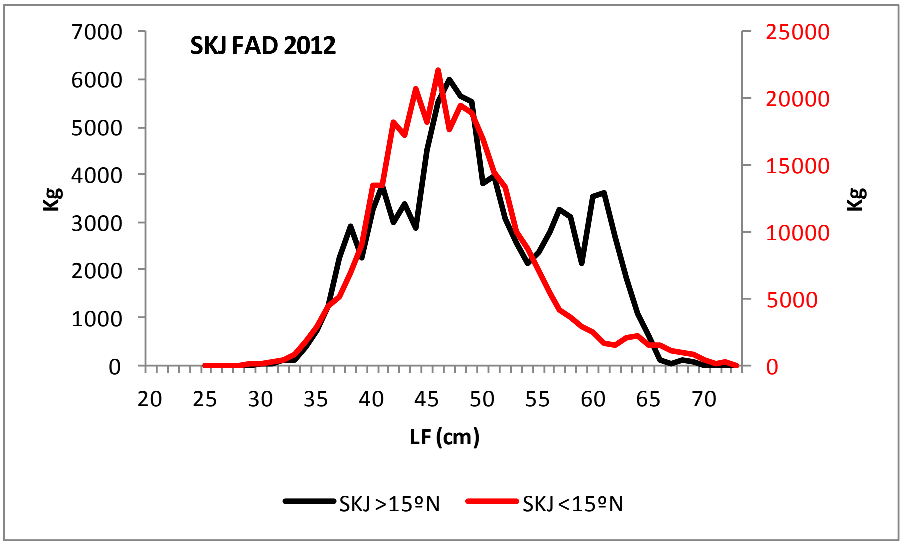


Figure 17. Distribution of weights over floating objects, inside and outside the area and period considered for 2012.

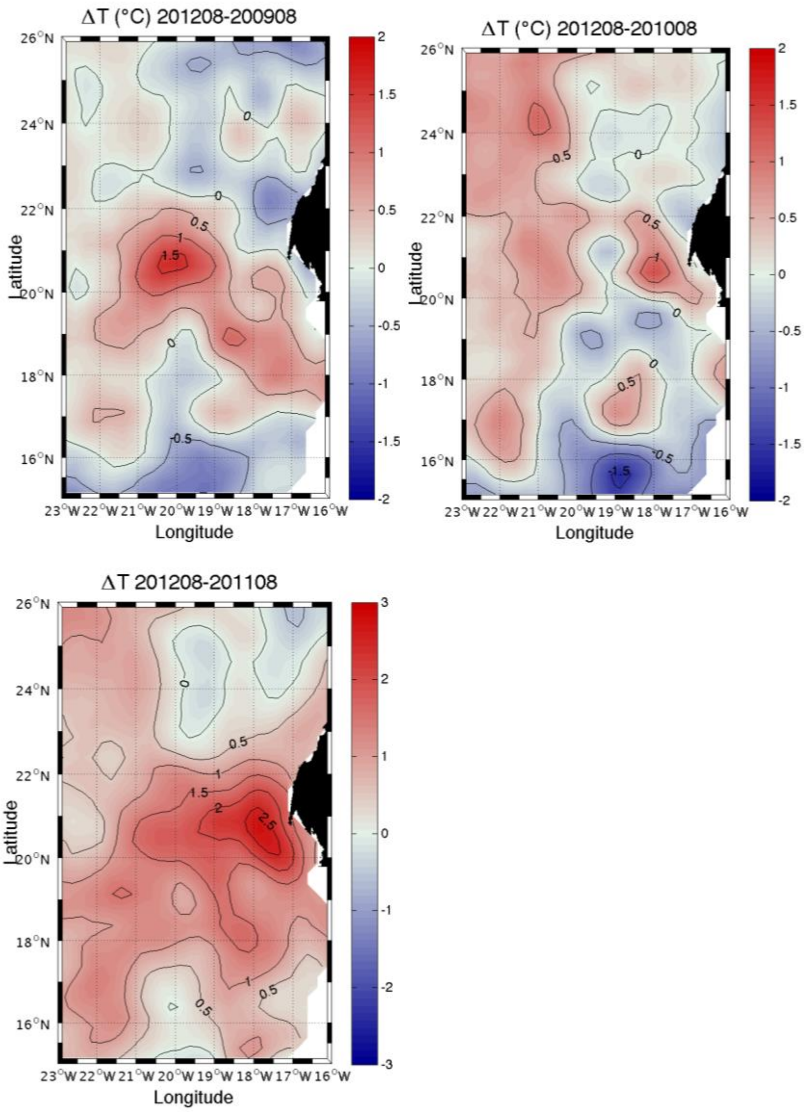


Figure 18. Differences in temperature between 2012 and 2009 (left), 2010 (centre) and 2011 (right) in August.

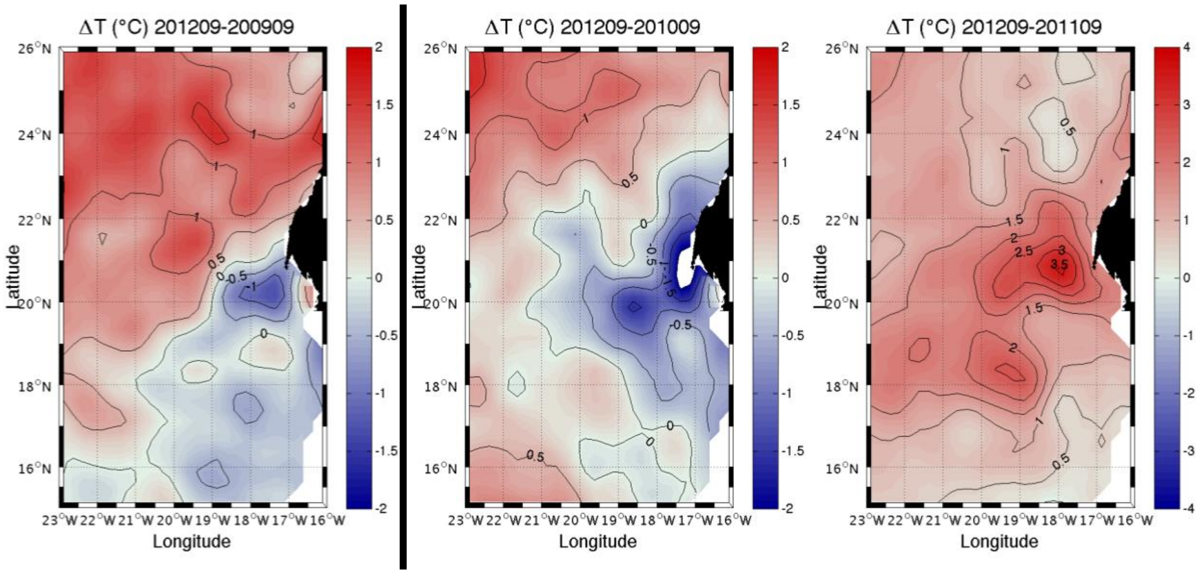


Figure 19. Differences in temperature between 2012 and 2009 (left), 2010 (centre) and 2011 (right) in September.

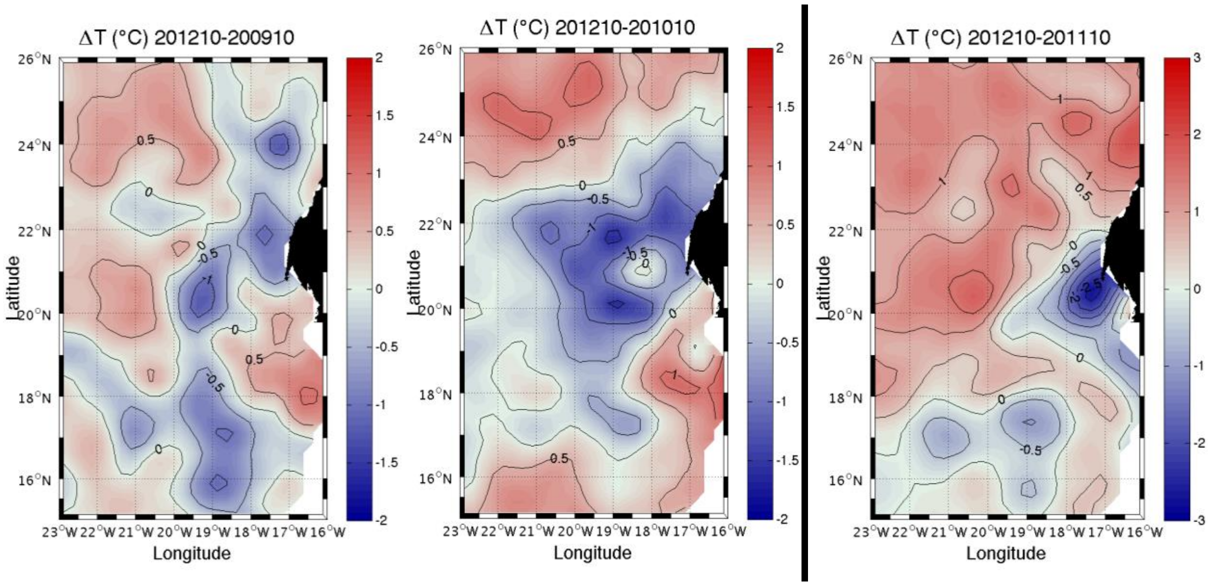


Figure 20. Differences in temperature between 2012 and 2009 (left), 2010 (centre) and 2011 (right) in October.

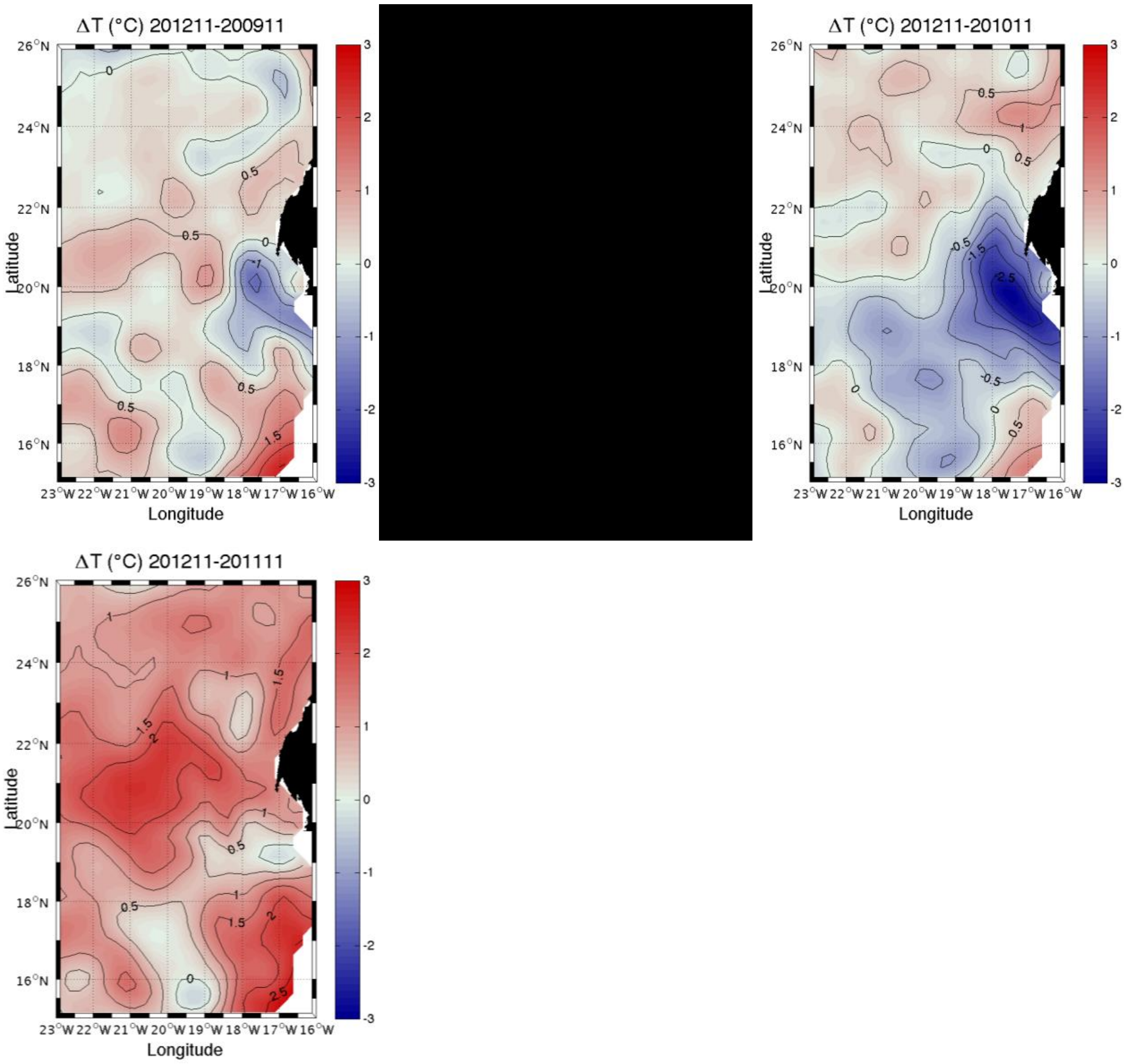


Figure 21. Differences in temperature between 2012 and 2009 (left), 2010 (centre) and 2011 (right) in November.

SCRS/2013/147 Collect. Vol. Sci. Pap. ICCAT, 70(6): 2787-2797 (2014)

DATOS ESTADÍSTICOS DE LA PESQUERÍA DE TÚNIDOS DE LAS ISLAS CANARIAS DURANTE EL PERIODO 1975 A 2012

Alicia Delgado de Molina[1], Rosa Delgado de Molina[1], J.Carlos Santana[1] y Javier Ariz[1]

SUMMARY

This document presents a summary of the development and current composition of the Canary Islands baitboat fleet and the catches made between 1975 and 2012. This paper also presents size histograms of the different species caught in 2012. An estimate of fishing effort was made, differentiating between vessels lesser than and greater than 50 GRT, taking into account that the former (vessels less than 50 GRT) carry out daily trips, with an average of 9 hours at sea, whereas the latter carry out trips lasting more than a day.

RÉSUMÉ

Ce document présente un résumé de l'évolution et de la composition actuelle de la flottille de canneurs des îles Canaries et des captures réalisées entre 1975 et 2012. Ce document présente également les histogrammes des tailles des différentes espèces capturées en 2012. Une estimation de l'effort de pêche a été réalisée, en distinguant les navires de moins et de plus de 50 TJB, étant donné que les navires de moins de 50 TJB réalisent des sorties quotidiennes, avec une moyenne de neuf heures en mer, alors que les autres navires réalisent des sorties de plus d'un jour.

RESUMEN

Este documento presenta un resumen de la evolución y composición actual de la flota de cebo vivo de las islas Canarias y de las capturas realizadas entre 1975 y 2012. Igualmente se presentan los histogramas de tallas de las distintas especies capturadas en 2012. Se ha realizado una estimación del esfuerzo de pesca nominal, distinguiendo entre barcos menores y mayores de 50 t de registro bruto, considerando que los primeros realizan mareas diarias, con una media de nueve horas de mar, mientras que los segundos realizan mareas superiores a un día.

KEYWORDS

Océano Atlántico, Túnidos tropicales, Cebo vivo, Captura, Esfuerzo, Distribución tallas

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1. Datos

Los datos de base para la elaboración del presente trabajo provienen de la red de información y muestreo que el Instituto Español de Oceanografía dispone en los principales puertos de descarga de túnidos de las Islas Canarias.

2. Resultados

En la **Tabla 1** se presenta la composición de la flota de cebo vivo que faena en el área de Canarias y costa noroccidental de África para el periodo comprendido entre 1990 y 2012, mientras que en la **Tabla 2** aparece el número de mareas y los días de mar realizados por los barcos mayores y menores de 50 toneladas de registro bruto.

La **Tabla 3** presenta las capturas realizadas en el área de Canarias en el periodo comprendido entre 1975 y 2012. Se observa que a partir de 2000 se produjo una importante disminución en las capturas debido, fundamentalmente, a la finalización del acuerdo de pesca con Marruecos.

La **Tabla 4** presenta el número de muestreos y el número de peces muestreados para el periodo 1995 – 2012 y en la **Tabla 5** aparecen las tallas y pesos medios, por especie, entre los años 1990 y 2012.

La **Figura 1** representa el número total de barcos y los mayores y menores de 50 trb de la flota de cebo vivo de Canarias, mientras que en la **Figura 2** aparece el número de mareas realizadas durante todo el periodo por dicha flota. En ambas figuras se aprecia una tendencia a la baja a partir de 1995, aunque en los últimos cuatro años se ve una ligera recuperación.

Las **Figuras 3 y 4** muestran las capturas para los túnidos templados y túnidos tropicales, respectivamente, mientras que en la **Figura 5** aparecen todas las especies. En la **Figura 6** se compara la composición específica para distintos años a lo largo del periodo considerado, observándose una gran variabilidad entre ellos.

En las **Figura 7** se muestran las distribuciones de tallas, por especie, para el año 2012.

En las **Figuras 8 y 9** aparecen los pesos medios de las distintas especies para el periodo 1987 – 2012.

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Tabla 1. Número de barcos de las flotas de cebo vivo (BB) que faenan en las áreas de Canarias y costa noroccidental de África para el periodo 1990 – 2012.

Año	*<10*	*10 – 19.9*	*20 – 49.9*	*50 – 99.9*	*> 100*	*Total*
1990	138	44	9	9	17	217
1991	147	42	9	12	22	232
1992	186	42	11	8	30	277
1993	138	40	8	7	18	211
1994	153	45	7	11	19	235
1995	152	41	13	12	20	238
1996	171	42	13	10	38	274
1997	178	50	15	10	18	271
1998	125	42	12	12	24	215
1999	152	39	16	10	26	243
2000	112	38	12	3	10	175
2001	142	38	12	11	20	223
2002	120	36	13	12	17	198
2003	104	39	11	7	16	177
2004	95	31	11	6	12	155
2005	127	45	14	8	13	207
2006	130	33	10	6	13	192
2007	92	26	7	7	13	145
2008	146	38	10	6	14	214
2009	144	28	10	5	11	198
2010	155	33	10	6	11	215
2011	150	34	9	6	12	211
2012	170	40	9	4	10	233

Tabla 2. Número de mareas (NM) y días de mar (DM) para el periodo 1990 – 2012 para los dos estratos en los que se ha dividido la flota.

	Nº mareas		**nº días mar**	
	<50 trb	**>50 trb**	**<50 trb**	**>50 trb***
1990	5524	290	5524	3190
1991	5858	380	5858	4180
1992	6211	340	6211	4420
1993	4425	325	4425	4225
1994	5624	339	5624	3051
1995	7745	307	7745	2763
1996	6745	455	6745	4095
1997	5516	488	5516	4392
1998	3226	402	3226	3618
1999	4998	506	4998	4554
2000	3397	98	3397	882
2001	2804	280	2804	2520
2002	2527	334	2527	3006
2003	3049	248	3049	2232
2004	3101	286	3101	2574
2005	4867	280	4867	2520
2006	4711	256	4711	2304
2007	2540	300	2540	2700
2008	5733	282	5733	2538
2009	3776	217	3776	1953
2010	5342	249	5342	2241
2011	3707	261	3707	2349
2012	7583	195	7583	1755

* Estimaciones

Tabla 3. Capturas (en toneladas) de túnidos en las Islas Canarias entre 1990 y 2012.

AÑO	BFT	YFT	ALB	BET	SKJ	OTH	TOTAL
1990	121	2213	138	3515	4322	25	10333
1991	59	2451	93	5129	5751	41	13523
1992	29	1493	299	5267	7128	37	14253
1993	31	1128	603	4376	2839	25	9002
1994	56	1329	160	9325	4772	25	15667
1995	4	801	657	7271	5143	20	13896
1996	157	2621	743	5253	4472	32	13278
1997	360	411	1045	5559	5884	39	13298
1998	39	3259	313	1034	5441	55	10141
1999	32	524	1972	6191	4119	31	12870
2000	26	146	240	2167	1120	44	3743
2001	55	15	1509	2543	1538	40	5700
2002	5	88	1114	1863	366	62	3497
2003	2	172	1312	3191	1417	53	6147
2004	5	213	680	2463	2093	54	5507
2005	35	106	731	2960	2882	225	6938
2006	73	292	325	2739	3005	67	6502
2007	123	199	255	1983	958	75	3595
2008	31	341	730	1768	3544	59	6474
2009	2	272	49	3030	1592	105	5049
2010	14	825	408	1754	1481	73	4557
2011	57	1280	330	3305	1257	105	6334
2012	54	88	1566	2260	7321	42	11337

Tabla 4. Número de muestreos (NM) y número de ejemplares muestreados (N.EJ) de las capturas en el área de Canarias, en el periodo comprendido entre 1995 y 2012.

AÑO	BFT		YFT		ALB		BET		SKJ		TOTAL	
	NM	N.EJ	NM	N.EJ	NM	N.EJ	NM	N.EJ	NM	N.EJ	NM	N.EJ
1995	-	-	22	750	7	206	119	14328	97	8361	245	23645
1996	8	22	63	5236	22	1656	56	6224	68	5053	217	18191
1997	14	118	36	1373	8	470	42	7700	72	4880	172	14541
1998	2	9	52	4095	8	222	16	790	58	4920	136	11396
1999	5	23	72	6016	41	3818	147	24247	111	6306	376	40410
2000	1	1	42	450	1	2	40	5549	28	1399	112	7401
2001	6	14	14	81	71	4023	123	10925	64	2906	278	17949
2002	3	9	10	220	113	7722	161	15421	48	1677	335	25049
2003	1	1	78	1597	58	5360	129	11886	62	3573	328	22417
2004	-	-	118	1863	50	3136	433	18196	137	4726	738	27921
2005	8	50	56	2850	11	470	105	13551	51	4131	231	21052
2006	10	82	73	920	9	228	150	14247	97	4365	331	19189
2007	70	418	38	1712	66	3101	232	25073	119	6287	525	36591
2008	13	116	206	2707	243	7104	274	21088	500	20804	1236	51819
2009	5	8	150	3828	18	827	289	34161	185	8064	647	46888
2010	20	49	311	6490	282	5913	410	22637	220	9859	1243	44948
2011	42	241	304	16676	101	4680	284	27901	313	12618	1044	62116
2012	49	100	105	1042	161	5982	201	18576	567	22763	1083	48463

Tabla 5. Peso medio en Kg (PM) de los ejemplares capturados por la flota de Canarias en el periodo de 1990 a 2012.

AÑO	YFT	BET	SKJ	BFT	ALB
1990	8	18	3	8	21
1991	17	16	3	137	25
1992	34	20	3	13	19
1993	26	17	3	-	27
1994	7	18	3	209	21
1995	24	21	3.7	-	26
1996	14	17	3	256	19
1997	7	13	3	177	18
1998	7	30	2.5	16	22
1999	10	14	3	231	17
2000	17	16	3.6	-	22
2001	10	22	3	155	15
2002	19	17	3.3	191	14
2003	16	13	2.6	-	15
2004	35	13	3.3	-	15
2005	11	19	2.7	164	18
2006	18	20	3	238	19
2007	22	21	2.6	153	15
2008	20	18	2.2	166	16
2009	10	12	1.9	149	8
2010	14	11	2.0	203	18
2011	13	15	3.7	176	13
2012	22	15	3.2	193	11

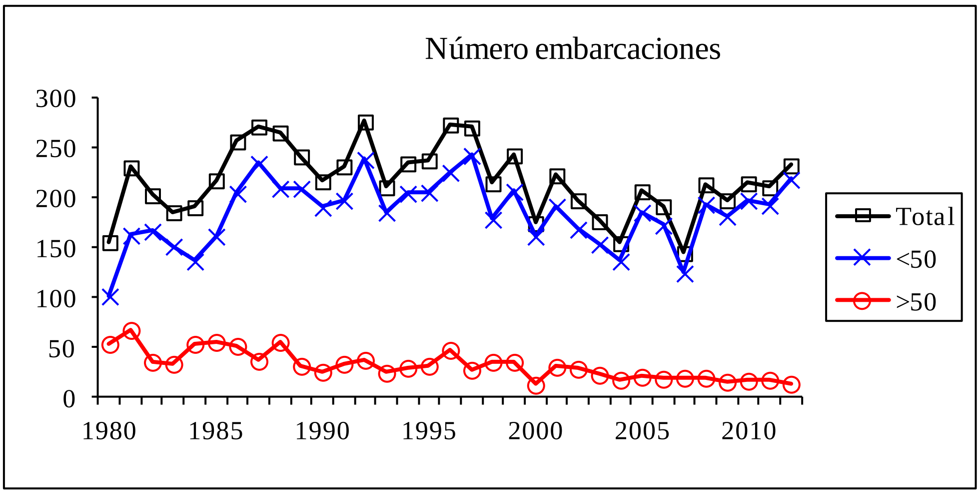

Figura 1. Barcos de la flota atunera de cebo vivo de Canarias (número total, mayores y menores de 50 TRB).

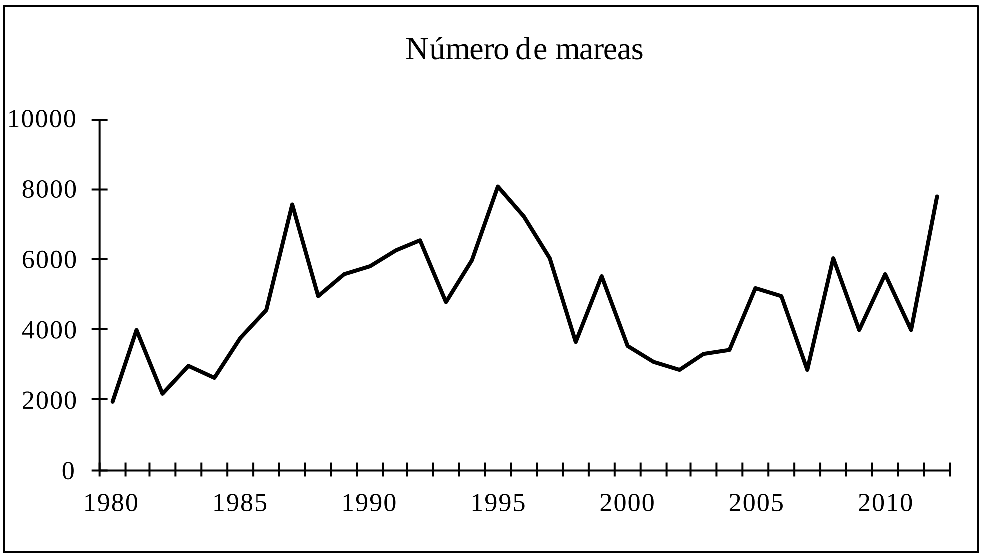

Figura 2. Número de mareas realizadas por la flota de cebo vivo de Canarias.

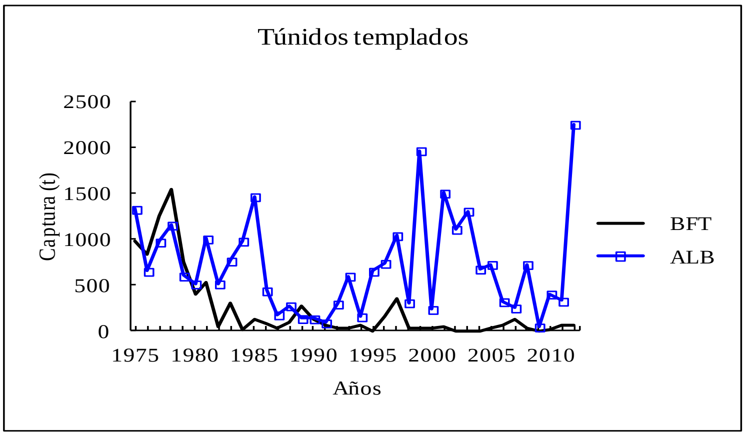

Figura 3. Capturas anuales de túnidos templados (atún rojo y atún blanco) en las Islas Canarias (1975 - 2012).

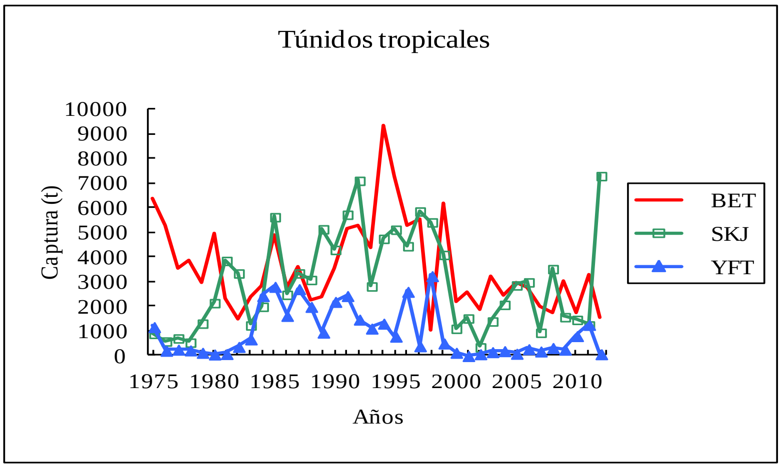

Figura 4. Capturas anuales de túnidos tropicales (patudo, listado y rabil) en las Islas Canarias (1975 - 2012).

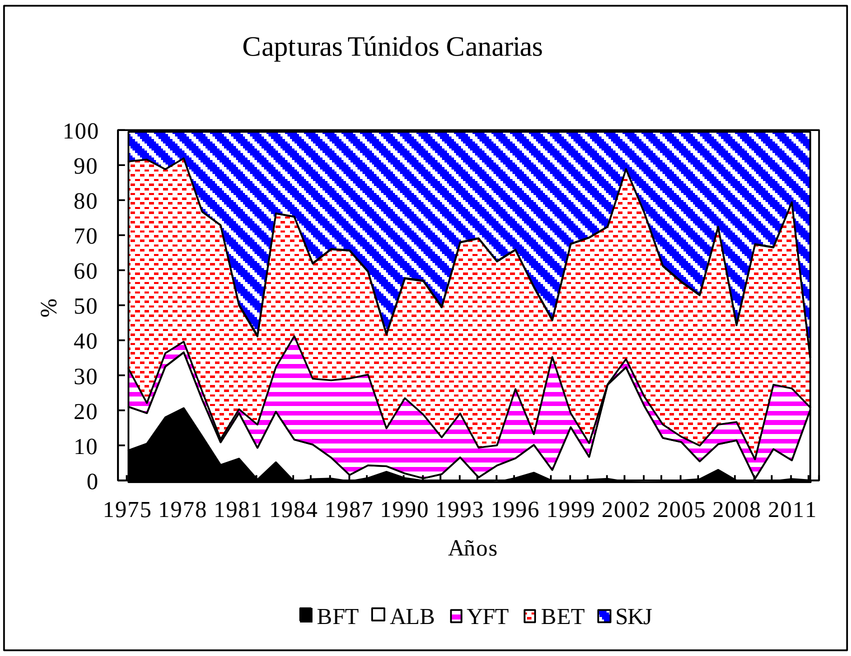

Figura 5. Capturas (en porcentaje) por especies, de las Islas Canarias (1975 - 2012).

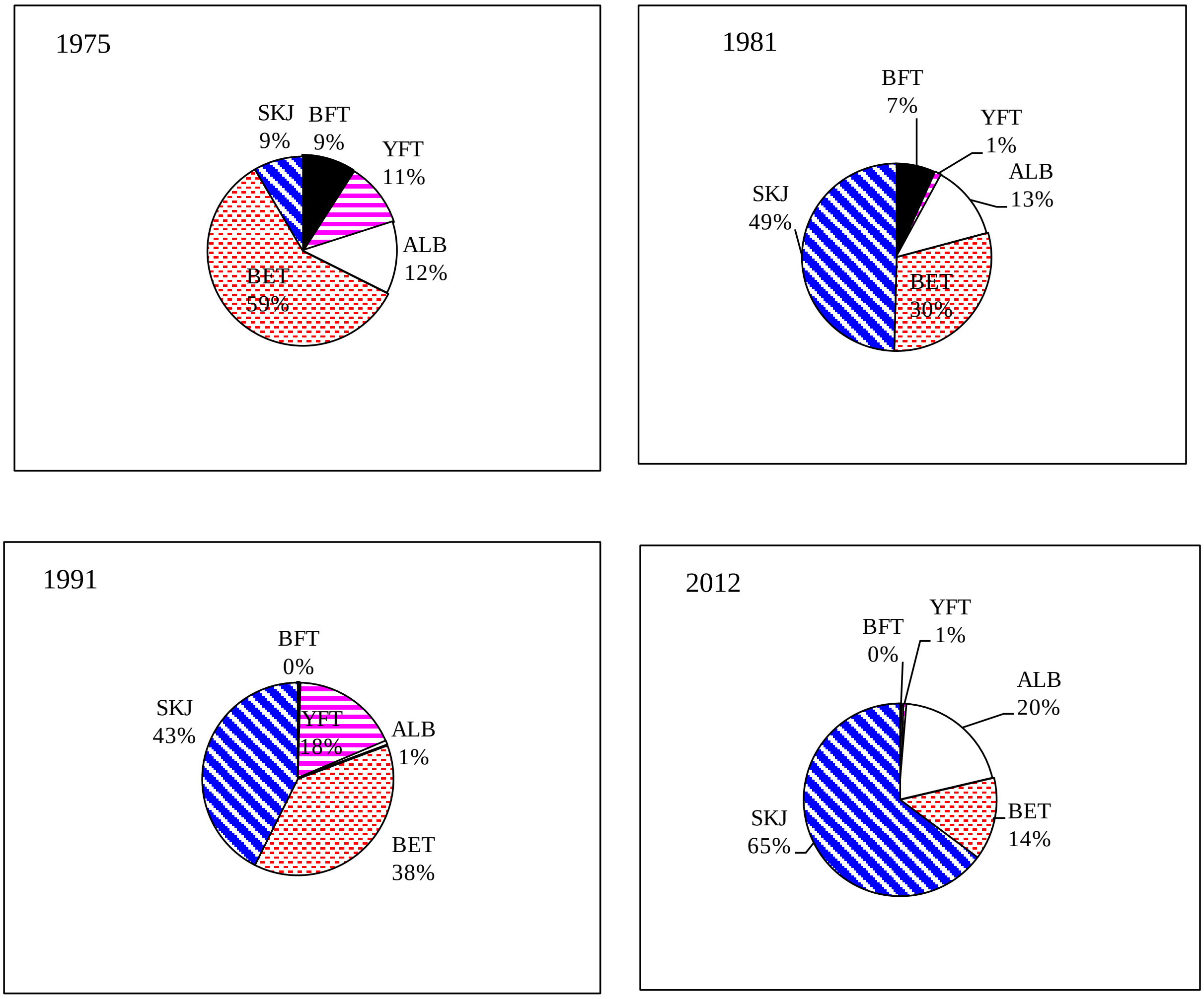

Figura 6. Porcentajes, por especies, de las capturas anuales de las Islas Canarias en 1975, 1981, 1991 y 2012.

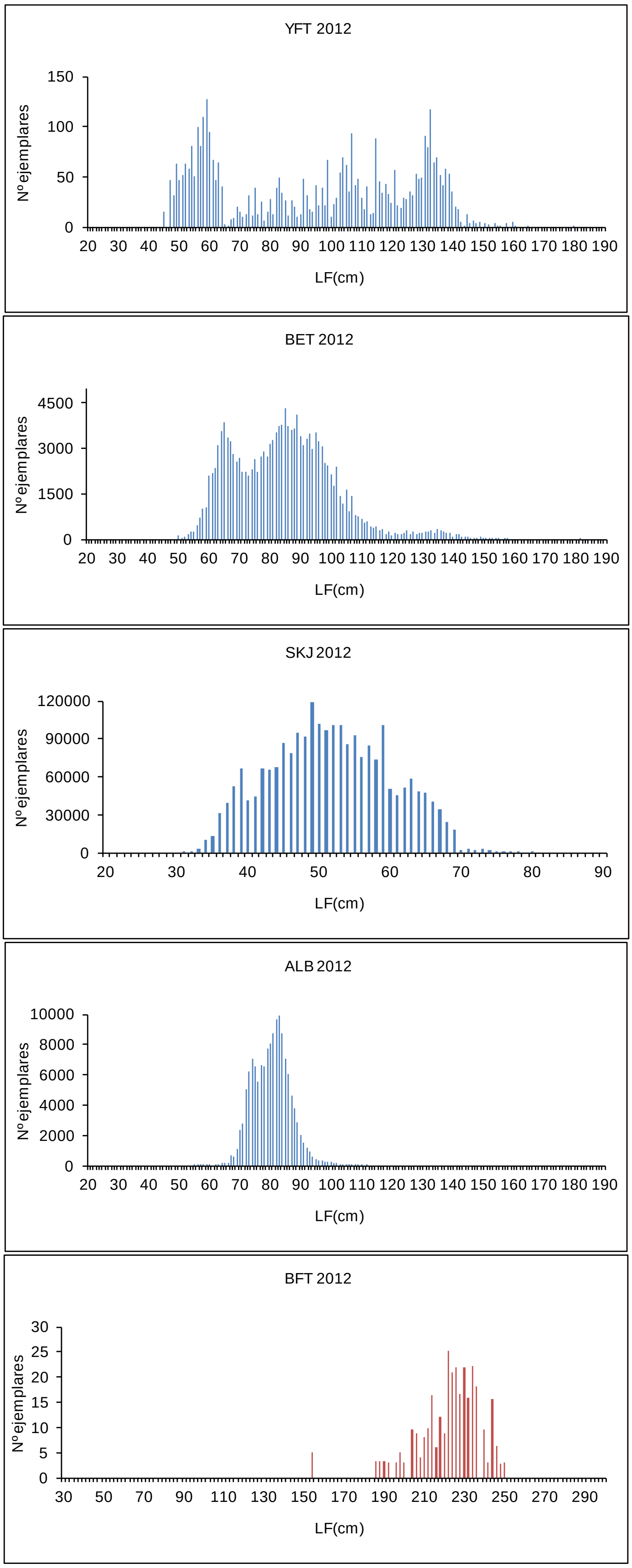

Figura 7. Distribuciones de tallas de rabil, patudo, listado, atún blanco y atún rojo de las capturas realizadas por la flota de cebo vivo de Canarias para 2012.

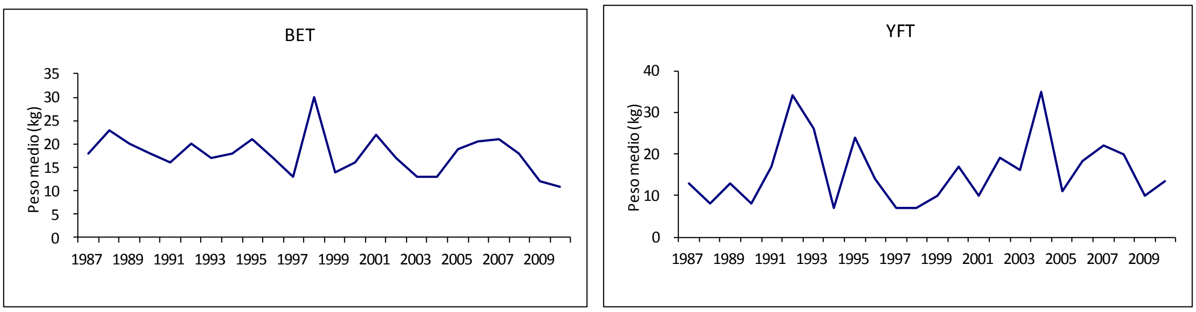

Figura 8. Pesos medios de patudo y rabil entre 1987 y 2012.

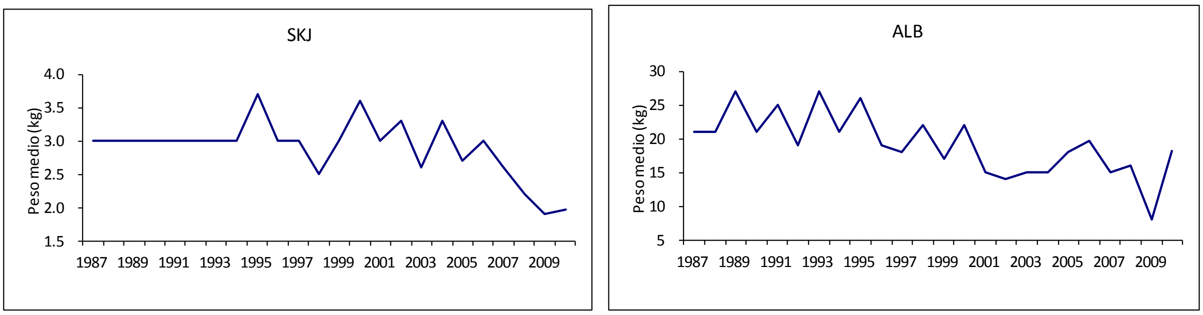

Figura 9. Pesos medios de listado y atún blanco entre 1987 y 2012.

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INFORMATIONS RECUEILLIES DANS LE CADRE DU PROGRAMME OBSERVATEUR DE LA PECHE THONIERE EN CÔTE D'IVOIRE

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SUMMARY

A national observer program was implemented in December 2012, in Ivory Coast by the 'Department of Fisheries and Aquaculture (DAP). Data collected by observers aboard the Ivorian purse seiner during a single trip in the framework of this national program, have been analyzed. These data were used to produce preliminary results particularly for occurrences of different bycatch species. The quantitative estimates of some species such as swordfish and the green turtle were also possible. However, the overall quantitative estimates and estimates per species have not been possible from these data. This preliminary analysis has highlighted gaps to fill in the current observer program to produce more interesting and reliable statistics.

RÉSUMÉ

La Direction de l'Aquaculture et des Pêches (DAP) a initié en décembre 2012 la mise en œuvre d'un programme observateur national. Les données collectées au cours d'une marée, dans le cadre de ce programme national, par les observateurs embarqués à bord du senneur battant pavillon ivoirien ont ainsi été analysées. Les données collectées ont permis de produire des résultats pertinents relatifs aux occurrences des différentes espèces accessoires capturées. Il a également permis d'obtenir les estimations quantitatives de certaines espèces comme l'espadon et la tortue verte. Toutefois les estimations quantitatives globales et par espèce accessoire n'ont pu être possible à partir de ces données. Cette analyse préliminaire a mis en évidence les manques à combler dans le programme observateur actuel, afin de produire des statistiques plus intéressantes et plus fiables.

RESUMEN

En diciembre de 2012, el Departamento de Pesca y acuicultura de Côte d'Ivoire implementó un programa nacional de observadores. Se han analizado los datos recopilados por los observadores a bordo del cerquero de Côte d'Ivoire durante una sola marea en el marco de este programa nacional. Estos datos se utilizaron para producir resultados preliminares, sobre todo para la presencia de diferentes especies de captura fortuita. También se pudieron obtener estimaciones cuantitativas de algunas especies como el pez espada y la tortuga marina. Sin embargo, no se han podido obtener estimaciones cuantitativas totales ni estimaciones por especies a partir de estos datos. Este análisis preliminar ha puesto de relieve la existencia de lagunas que tienen que cubrirse en el programa actual de observadores para producir estadísticas más interesantes y fiables.

KEYWORDS

Tuna statistics, Observer programmes

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1. Introduction

Les programmes nationaux d'observateurs constituent une source d'informations fines, complémentaires aux données recueillies de débarquement et aux déclarations des livres de bord. Ces programmes permettent notamment d'évaluer les quantités et la composition spécifique des prises accessoires et des rejets, nécessaires à une meilleure appréhension des captures totales des pêcheries. La Direction de l'Aquaculture et des Pêches (DAP) du Ministère des Ressources Animales et Halieutiques a initié la mise en place du programme observateur hauturier dès la fin de l'année 2012. Ce programme observateur consiste à embarquer des observateurs à bord des bateaux battant pavillon ivoirien.

Le présent document a pour objectif de fournir les informations recueillies dans le cadre de ce programme national de collecte de données.

2. Méthodes

Les données ont été collectées en 2012, au cours d'une marée, par un observateur de la Direction de l'Aquaculture et des Pêches à bord du thonier senneur ivoirien. Elles ont été recueillies à l'aide de formulaires papiers puis saisies dans une base de données relationnelle. Cette marée de 2012 s'est déroulée sur 30 jours de mer, durant le mois de décembre, dans l'océan Atlantique.

3. Résultats

Aucun coup de senne sous banc libre n'a été effectué au cours de cette marée. Les données de route collectées par l'observateur ont permis de confirmer l'exactitude des positions de coup de senne déclarées dans le livre de bord du bateau. Cependant, les estimations quantitatives précises par espèce n'ont pu être réalisées ni pour les captures accessoires, ni pour des thonidés. Les données ont permis néanmoins d'avoir des informations sur les fréquences d'occurrence des espèces accessoires, les structures de taille et les estimations quantitatives nominales pour les espadons et les tortues.

L'analyse descriptive des données montre que les captures accessoires sont composées d'une dizaine d'espèces dont les plus occurrentes sont *Coryphaena hippurus, Elagatis bipinnulata, Canthidermis maculata*, *Decapterus spp* et *Acanthocybium solandri* (**Figure 1**). Les espadons apparaissent dans 25% des coups de senne, comme les balistes. Les captures accessoires comprennent également des tortues et des requins qui apparaissent rarement.

Au total, 13 espadons (*Xiphias gladius*) et 7 tortues vertes (*Chelonia mydas*) ont été pêchés au cours de cette marée. Les mensurations ont porté sur 12 espadons et 3 tortues (**Figures 2 et 3**). La capture accessoire totale estimée par l'observateur est de 16,59 tonnes, soit un ratio de 2,9% par rapport à la capture de thons conservée.

4. Discussion et conclusión

Le ratio de 2,9% obtenu à partir des données de cette marrée est assez proche de ceux obtenus dans les calées sous objet flottant dans le Pacific Ouest et Est mais très en deçà du ratio de 15% obtenu dans la pêcherie thonière européenne à la senne en Atlantique (Amandè et al, 2010 ; Dagorn et al, 2011).

Le programme observateur initié par la Direction de l'Aquaculture et des Pêches en Côte d'Ivoire démontre la volonté de l'État de Côte d'Ivoire à s'inscrire dans la dynamique de production de données fines nécessaires à l'amélioration des évaluations des stocks gérées par l'ICCAT. Cette marée dont les résultats sont présentés dans ce document se veut d'être interprétée comme une marée d'initiation à la mise en œuvre d'un programme observateur national. En effet, les estimations quantitatives par espèce n'ont été possibles que pour l'espadon et la tortue verte. Il convient d'améliorer la collecte des données observateurs et de veiller à couvrir l'ensemble des marées de la flottille, d'autant plus qu'il s'agit d'un seul navire.

Remerciements

Nous remercions la Direction de l'Aquaculture et des Pêches (DAP) pour la collaboration et la mise à disposition de ces données. Nous remercions également la société BigEye pour ses conseils et son implication en vue d'améliorer le programme observateur courant.

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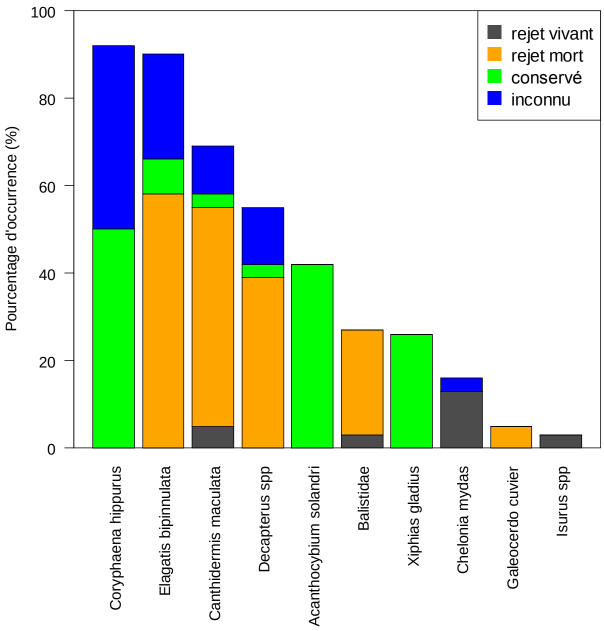

Figure 1. Nombre d'occurrence et devenir des prises accessoires par espèce

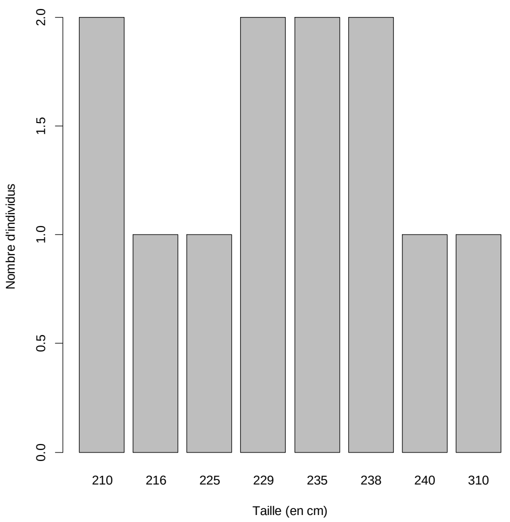

Figure 2. Structure de taille des espadons (*Xiphias gladius*)

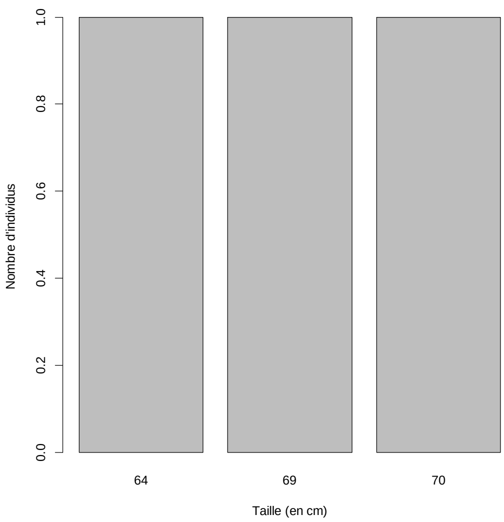

Figure 3. Structure de taille des tortues vertes (*Chelonia mydas*)

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STATISTIQUES DE LA PÊCHERIE THONIERE IVOIRIENNE DURANT LA PERIODE EN 2012

Amandè M.J.[1 ¤], Konan K.J.[1], Diaha N.C.[1] et Tamégnon A.

SUMMARY

This document presents the statistics for 2012 for offshore tuna fishing in Côte d'Ivoire. It includes the information regarding catches and landings of the fleet of Côte d'Ivoire. These statistics are based on logbook data, obtained from samples from landing ports following the purchasing process, tuna validation software (AVDTH). Likewise, it includes an update of landings destined to the local market (faux poisson) by the fleet of Côte d'Ivoire. The purse seine fishing sets of the fleet of Côte d'Ivoire are mainly carried out on floating objects (98%). Tuna catches include 83% skipjack, 12% yellowfin and 5% bigeye. The size structure of the fish measured shows that more than 90% of the fish landed (100% for landings on the local market), measure between 30 and 50 cm. Nearly 14% of purse seine fishing sets are carried out in Côte d'Ivoire's EEZ, corresponding to a total quantity caught of 391.7 t in 2012. Local market supply by Côte d'Ivoire's fleet is relatively important with a quantity of landed faux poisson corresponding to 1,325 t in 2012, i.e. 32% of the total landings of the fleet in Abidjan.

RÉSUMÉ

Ce document présente les statistiques de l'année 2012 de la pêche thonière hauturière en Côte d'Ivoire. Il intègre les informations relatives aux captures et débarquements de la flottille ivoirienne. Ces statistiques sont basées sur les données des livres de bord, celles issues des échantillonnages dans les ports de débarquement suivant le processus d'acquisition, validation des données thonières (AVDTH). Il intègre également une mise à jour des débarquements destinés au marché local « faux-poisson » par la flottille ivoirienne. Les coups de senne de la flottille ivoirienne sont essentiellement effectués sur objets flottants (98%). Les prises de thonidés sont composées de 83% de listao, 12% d'albacore et 5% de patudo. La structure de taille des individus mesurés montre que plus de 90% des individus débarqués (100% pour les débarquements sur le marché local) ont une taille comprise entre 30 et 50 cm. Près de 14% des coups de senne sont effectués dans la ZEE ivoirienne, correspondant à une quantité totale capturée de 391,7 tonnes en 2012. L'approvisionnement du marché local par la flottille ivoirienne est relativement important, avec une quantité de faux-poissons débarqués correspondant à 1.325 tonnes en 2012, soit 32% de l'ensemble des débarquements de la flottille à Abidjan.

RESUMEN

Este documento presenta las estadísticas del año 2012 de la pesca atunera de altura de Côte d Ivoire. Incluye información relativa a las capturas y los desembarques de la flota de Côte d'Ivoire. Estas estadísticas se basan en los datos de los cuadernos de pesca, en datos procedentes de los muestreos en los puertos de desembarque que siguen el proceso de adquisición y en la validación de datos atuneros (AVDTH). Incluyen asimismo una actualización de los desembarques destinados al mercado local (faux poisson) realizados por la flota de Côte d'Ivoire. Los lances con cerco de la flota de Côte d'Ivoire se realizan principalmente sobre objetos flotantes (98%). Las capturas de túnidos se componen principalmente de un 83% de listado, un 12% de rabil y un 5% de patudo. La estructura de las tallas de los ejemplares medidos demuestra que más del 90% de los ejemplares desembarcados (el 100% para los desembarques en el mercado local) tienen una talla entre 30 y 50 cm. Aproximadamente el 14% de los lances de cerco se realizan en la ZEE de Côte d'Ivoire y corresponden a una cantidad total capturada de 391,7 t en 2012. El aprovisionamiento del mercado local que realiza la flota de Côte d'Ivoire es relativamente importante, con una cantidad de faux poisson desembarcada que corresponde a 1.325 t en 2012, es decir el 32% del conjunto de los desembarques de la flota en Abiyán.

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KEYWORDS

Fishery statistics, Catch Data, Samping

Tableau 1. Capacité de transport, efforts de pêche (jours de pêche et jours de recherche), nombre de carrés CWP visités, avec au moins une calée, avec des captures.

Capacité de transport	800
Nombre de thonier	1
Nombre de jours de pêche	178
Nombre de jours de recherche	179
Nombre de carrés CWP visités	120
Nombre de carrés CWP avec au moins une calée	99
Nombre de carrés CWP avec des captures	97

Tableau 2. Nombre de calées (total, positives et nulles) selon le mode de pêche.

	Positives	*Nulles*	*Totales*
Sous objets flottants	170	167	3
Sous bancs libres	4	2	2
Tous types de banc	174	169	5

Tableau 3. Prises par espèces (en tonnes) : tous modes de pêche confondus, sur objets flottants et sur bancs libres

	YFT	*SKJ*	*BET*	*ALB*	*Autres*
Sous objets flottants	337	2350	131	0	2.42
Sous bancs libres	0	27	0	0	0
Tous types de banc	337	2377	131	0	2.42

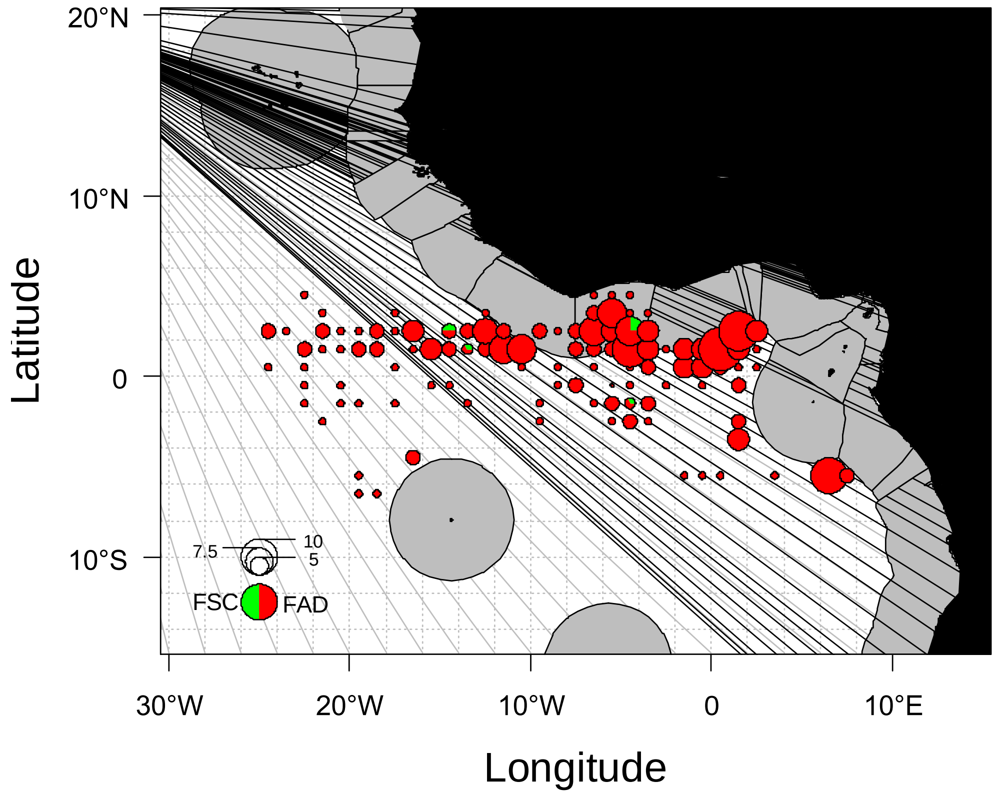

Figure 1. Distribution des coups de senne selon le mode de pêche (FAD=Objets flottants et FSC=Bancs libres)

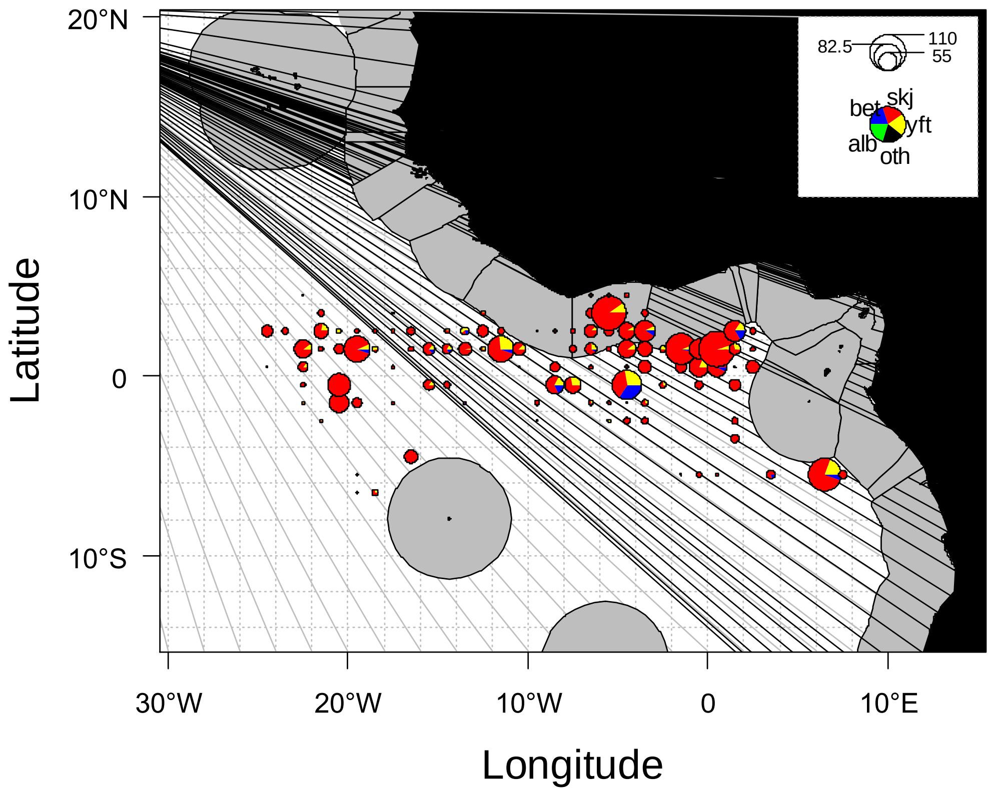

Figure 2. Distribution des captures par espèce

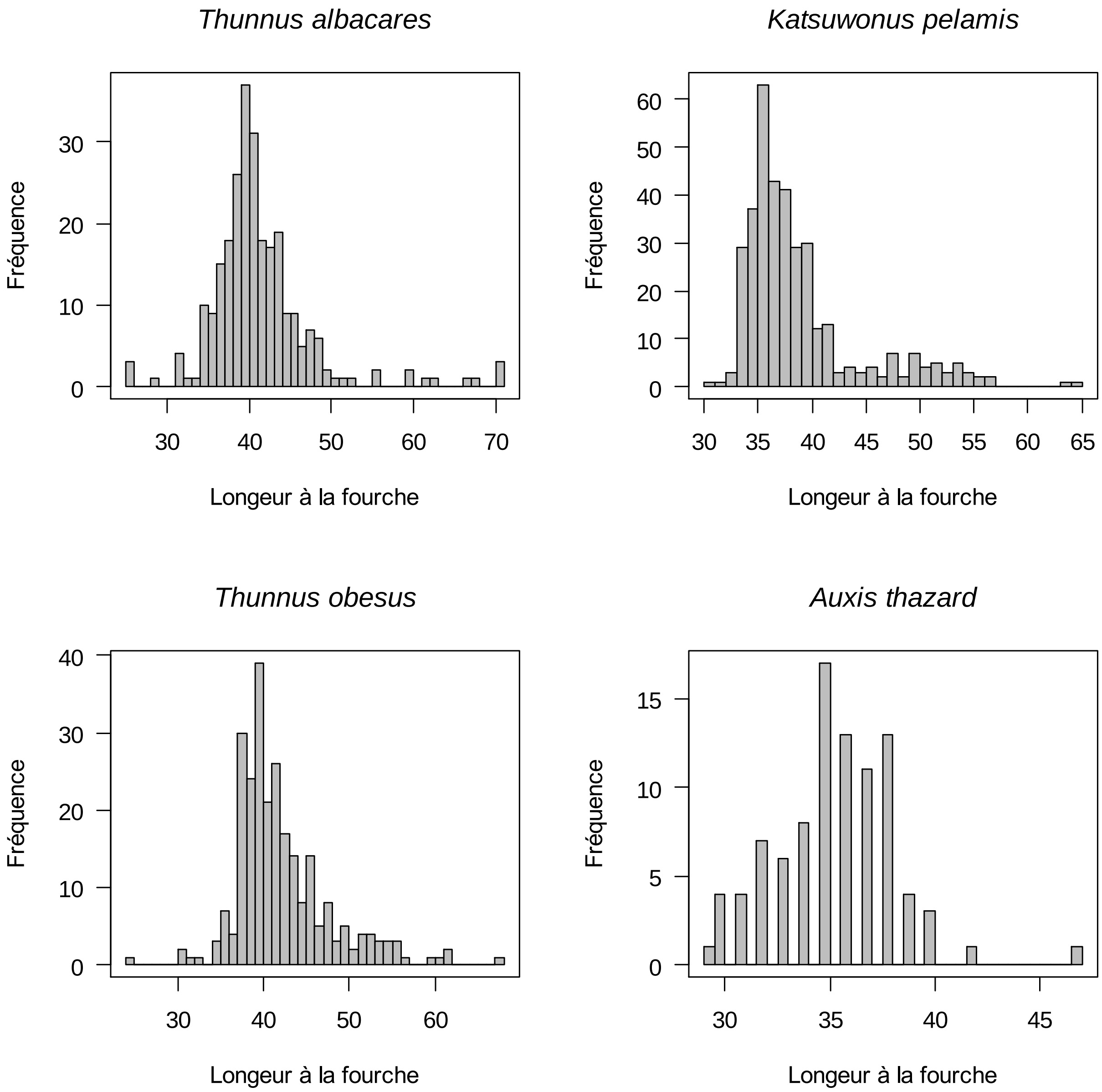

Figure 3. Fréquence de taille des thonidés par espèce dans les débarquements de poissons destinés aux conserveries.

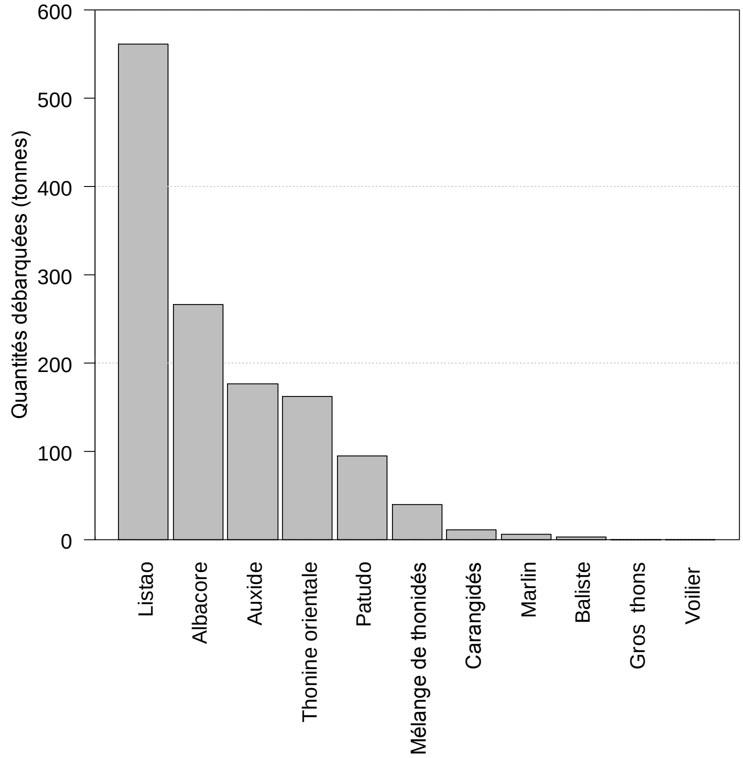

Figure 4. Quantités totales de faux-poisson débarqués par espèce

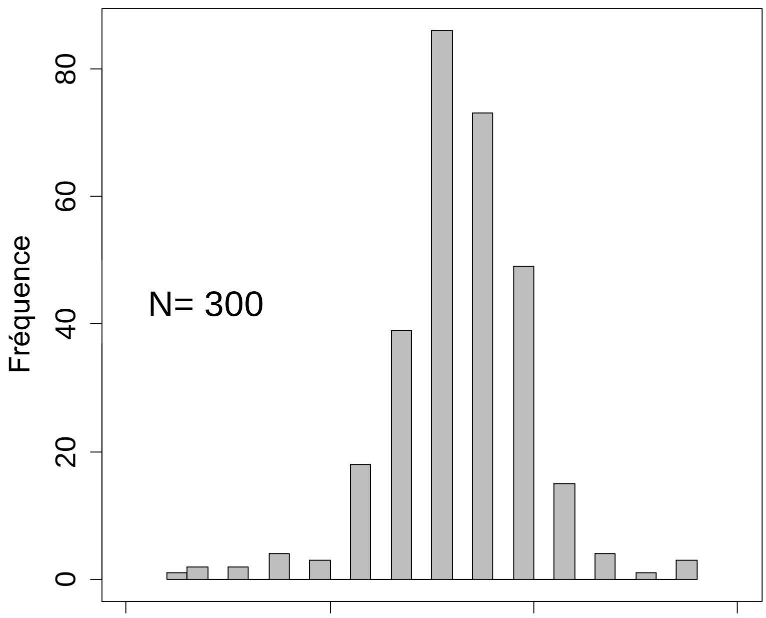

Figure 5. Fréquence de tailles des thonidés dans les débarquements de faux-poisson.

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RÉVISION DES CAPTURES ANNUELLES PAR ENGIN DE THONIDÉS AU CAP VERT DE 2005 À 2012

Vanda Marques da Silva Monteiro[1] et Carlos Palma[2]

SUMMARY

After several years of delay of statistical data of the National Institute for Fisheries Development, due to different problems, including those related to the statistical programme, the final data are available from 2005 to 2012. These data relate to Cape Verde's artisanal, semi-industrial and industrial fishing fleet for tropical tunas and small tunas caught in the EEZ of Cape Verde and beyond. Although the new software will be used only from 2013, the final data shall update ICCAT statistics and, from now on, annually, Cape Verde hopes to provide the final data of the previous year.

RÉSUMÉ

Après plusieurs années de retard dans les données statistiques de l'Institut National pour le Développement des Pêches, en raison de divers problèmes, dont celui lié au programme statistique, les données finales sont disponibles de 2005 à 2012. Celles-ci se rapportent à la pêche artisanale, semi-industrielle et industrielle de la flotte Cap-verdienne pour les thons tropicaux et les thons mineurs capturés dans la ZEE du Cap Vert et au-delà. Même si le nouveau logiciel sera appliqué seulement à partir de 2013, les données définitives mettront à jour les statistiques de l'ICCAT et à partir de maintenant nous pensons fournir chaque année les données finales de l'année précédente.

RESUMEN

Tras varios años de retraso en los datos estadísticos del Instituto nacional para el desarrollo pesquero, debido a diversos problemas, incluido el relacionado con el programa estadístico, los datos finales para 2005 a 2012 están ya disponibles. Son datos sobre la pesca artesanal, semiindustrial e industrial de la flota de Cabo Verde de túnidos tropicales y pequeños túnidos capturados en la ZEE de Cabo Verde y más allá. Aunque el nuevo programa se aplicará a partir de 2013, los datos definitivos serán una actualización de las estadísticas de ICCAT y a partir de ahora se enviarán cada año los datos finales del año precedente.

KEYWORDS

Statistiques, Thonidés tropicaux, Logiciel, Pêche artisanale, Pêche semi-industrielle

1. Base de données

Les données de thon et thons mineurs présentées dans ce document proviennent de la base de données en ACCESS, EXCEL et avec macros programmées pour extraire les cartes finales. Cette base de données de l'Institut National pour le Développement de la Pêche à Mindelo, au Cap-Vert, a été seulement d'introduction, sans le traitement des données, ce qui n'était pas le plus approprié, en donnant diverses erreurs, parfois de difficile résolution dans l'analyse.

A côté, plusieurs projets ont été lancés afin de combler le retard, mais n'a pas atteint la fin, car il a été conclu que aussi n'était pas les plus appropriés.

Au moment le nouveau logiciel a été conçu, mais il manque encore compléter / terminer certains modules :

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1. Terminer la programmation (nouveau software du Système de gestion des statistiques);
2. Tester le système des tablettes (système portable de recueille des données);
3. Commencer avec un nouveau programme (informatiser les données dans le nouveau software);
4. Convertir les anciennes bases de données.

2. Résultats de la structuration de la base

Un logiciel complètement nouveau a été déjà conçu, mais nécessite encore de validation pratique.

Il manque compléter / terminer quelques modules du programme. Le système tablets sera testé dans les prochains jours. Le reste continue la même chose. Nous attendons pour le programme pour commencer réellement à entrer les informations dans le nouveau système et à posteriori convertir la vieille base de données. Les données de 2013 seront introduites dans ce nouveau logiciel, qui a été d'abord testé en novembre / décembre 2012, quand tous techniques professionnels, des différentes îles, ont été reçu une formation.

Avec la restructuration, les données actuellement disponibles à ICCAT (**Tableaux 3** et **4**) devraient être remplacés par le nouveau propos de révision (**Tableaux 1** et **2**). La nouvelle proposition est le résultat de la révision / mise à jour des données statistiques au niveau national, et est plus complète et fiable, ce qui permettra d'améliorer considérablement les statistiques de l'ICCAT existants dans la Tâche 1 (**Figure 1**).

3. Conclusion

Le Cap-Vert dispose à partir de cette année des données statistiques de pêche actualisées, centrées dans l'INDP, avec une plus grande robustesse et cohérence, plus grande couverture des besoins en termes d'accessibilité, de sécurité et de fiabilité, et de fournir chaque année les données finales de l' année précédente. A travers des tableaux ci-dessous, on peut voir les différences entre les données du nouveau propos de révision et les données actuellement disponibles à ICCAT.

Tableau 1. Tâche 1 actualisée. Captures (kg) par espèce et stock pour la période 2005-2012.

				Year							
Species group	Species	ScieName	Stock	2005	2006	2007	2008	2009	2010	2011	2012
Tuna (major sp.)	ALB	Thunnus alalunga	ATS	8000	46000	24000		5000		5000	
	BET	Thunnus obesus	A+M	1077000	1406000	1247000	445000	545000	554000	1037000	713000
	SKJ	Katsuwonus pelamis	ATE	7157000	4754000	5453000	4682000	4909000	5155019	7883317	5534748
	YFT	Thunnus albacares	ATE	6019000	5648000	4568000	7905000	4638000	5856041	6002254	4602599
Tuna (major sp.) Total				**14261000**	**11854000**	**11292000**	**13032000**	**10097000**	**11565060**	**14927571**	**10850347**
Tuna (small)	FRI	Auxis thazard	ATL	300000	318000	378000	574000	1312000	711036	853107	1810918
	LTA	Euthynnus alletteratus	ATL	81000	123000	292000	250000	357000	185164	102148	131489
	WAH	Acanthocybium solandri	A+M	449000	555000	524000	351000	472000	470115	470360	445329
Tuna (small) Total				**830000**	**996000**	**1194000**	**1175000**	**2141000**	**1366315**	**1425615**	**2387736**
TOTAL				**15091000**	**12850000**	**12486000**	**14207000**	**12238000**	**12931375**	**16353186**	**13238083**

Tableau 2. Détail des captures (kg) totales (Tâche I dans le **Tableau 1**) par engin, espèce, flottille de pêche et stock pour la période 2005-2012.

				Year							
GearCode	**Species**	**Fleet**	**Stock**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
BB	SKJ	CPV	ATE	57000		168000	67000	43000			71673
	YFT	CPV	ATE	1000		3000	2000				4961
	FRI	CPV	ATL	4000							
	LTA	CPV	ATL								199
	WAH	CPV	A+M								1947
BB Total				62000		171000	69000	43000			78780
HAND	BET	CPV	A+M	1000	1000	1000	1000	1000	1000	1000	1000
	SKJ	CPV	ATE	21000	23000	13000	19000	82000	57436	17360	12986
	YFT	CPV	ATE	985000	1218000	1048000	648000	1121000	1053637	800152	1163769
	FRI	CPV	ATL	5000	2000	6000	28000	18000	1158	5050	5275
	LTA	CPV	ATL	14000	17000	14000	13000	6000	10333	14612	36734
	WAH	CPV	A+M	445000	552000	520000	337000	448000	430897	467060	436875
HAND Total				1471000	1813000	1602000	1046000	1676000	1554461	1305234	1656639
LL	YFT	CPV-Ind	ATE		15000						
LL Total					15000						
PS	ALB	CPV-ETRO	ATS	8000	46000	24000		5000		5000	
	BET	CPV-ETRO	A+M	1076000	1405000	1246000	444000	544000	553000	1036000	712000
	SKJ	CPV	ATE	212000	500000	120000	297000	467000	473583	633957	224089
		CPV-ETRO	ATE	6867000	4231000	5152000	4299000	4317000	4624000	7232000	5226000
	YFT	CPV	ATE	6000	13000	15000	7000	13000	17404	5102	2869
		CPV-ETRO	ATE	5027000	4402000	3502000	7248000	3504000	4785000	5197000	3431000
	FRI	CPV	ATL	160000	193000	194000	229000	384000	322878	514057	1189643
		CPV-ETRO	ATL	131000	123000	178000	317000	910000	387000	334000	616000
	LTA	CPV	ATL	45000	106000	278000	237000	351000	174831	87536	94556
		CPV-ETRO	ATL	22000							
	WAH	CPV	A+M	4000	3000	4000	14000	24000	39218	3300	
		CPV-ETRO	A+M								6507
PS Total				13558000	11022000	10713000	13092000	10519000	11376914	15047952	11502664
TOTAL				**15091000**	**12850000**	**12486000**	**14207000**	**12238000**	**12931375**	**16353186**	**13238083**

Tableau 3. Tâche 1 actuelle dans la base de données de ICCAT. Captures (kg) par espèce et stock de la période 2000-2011.

				Year											
Species group	**Species**	**ScieName**	**Stock**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Tuna (major sp.)	**ALB**	Thunnus alalunga	ATN										5000		
			ATS						7720	45767	14980				5000
	BET	Thunnus obesus	A+M	2000		1000	1000	1000	1091540	1436911	1146540	1069000	552780	1164000	1037000
	SKJ	Katsuwonus pelamis	ATE	789000	794000	398000	343000	1096973	7504052	7929996	6026300	6010000	5559800	6031742	7758000
	YFT	Thunnus albacares	ATE	1851000	1684000	1802000	1867743	3236425	7154270	8111662	4057050	8413000	5505200	4492045	5987000
Tuna (major sp.) Total				**2642000**	**2478000**	**2201000**	**2211743**	**4334398**	**15757582**	**17524336**	**11244870**	**15492000**	**11622780**	**11687787**	**14787000**
Tuna (small)	**FRI**	Auxis thazard	ATL	81000	171000	278000	264000	344000	298360	543887	337120	832000	1706710	743622	672000
	LTA	Euthynnus alletteratus	ATL	491000	178000	262000	143000	137000	61732	160000	348000	518000	855350	402159	134000
	WAH	Acanthocybium solandri	A+M	487000	578000	500000	343000	458000	44516	537000	454000	811000	745450	470147	418000
Tuna (small) Total				**1059000**	**927000**	**1040000**	**750000**	**939000**	**404608**	**1240887**	**1139120**	**2161000**	**3307510**	**1615928**	**1224000**
TOTAL				**3701000**	**3405000**	**3241000**	**2961743**	**5273398**	**16162190**	**18765223**	**12383990**	**17653000**	**14930290**	**13303715**	**16011000**

Tableau 4. Détails des captures (kg) totales (Tâche I en **Table 3**) par engin, espèce, flottille de pêche et stock de la période 2000-2011.

				Year											
GearC	Spec	Fleet	Sto	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
BB	BET	CPV	A+										1000		
	SKJ	CPV	AT	7700	4440			5740	57000	57000			43000	43350	
		CPV-	AT				1780					76000	10035		
	YFT	CPV	AT	4570	2980			1379							
		CPV-	AT				3000					2000			
	FRI	CPV	AT	7200											
	LTA	CPV	AT	1930											
	WA	CPV	A+	7200	4100										
BB				1564	7830		1810	1436	57000	57000		78000	14435	43350	
HAN	BET	CPV	A+	2000		1000	1000							1000	1000
		CPV-	A+					1000	10	700					
		CPV-	A+									1000	3080		
	SKJ	CPV	AT	1900	5000	3200							82000	81703	61000
		CPV-	AT				4300						15300		
		CPV-	AT				6800						17970		
	YFT	CPV	AT	1388	1374	9180							11210	11201	11090
		CPV-	AT				1257	1500	18950	18450	12400	55300	65500		
		CPV-	AT				3600					13300	19960		
	FRI	CPV	AT	9000	1100	1810							18000	6215	1000
		CPV-	AT				4900						8000		
	LTA	CPV	AT	2500	3300	2090							6000	18447	10000
		CPV-	AT										14000		
		CPV-	AT				2000					13800	400		
	WA	CPV	A+	4150	5340	3410							44800	44789	40200
		CPV-	A+				3100	3647	4670	50320	41400	28000	21000		
		CPV-	A+				3000					53000	41230		
HAN				1858	2002	1682	2120	1866	18996	23489	16540	11580	31032	16754	15840
LL	YFT	CPV-	AT				2000					4000			
LL							2000					4000			
PS	ALB	CPV-	AT										5000		
			AT						7720	45767	14980				5000
	BET	CPV-	A+						10760	14359	11455	10680	54400	11630	10360
		CPV-	A+						15530	300	1000		4700		
	SKJ	CPV	AT		3000	3660									
		CPV-	AT				1000	3562	33300	24454	46000	91000			
		CPV-	AT						68670	70009	57013	56540	47840	59066	76970
		CPV-	AT				5300	6832	24705	62754	27900	18900	37948		
	YFT	CPV	AT	6000	1200	8840	2327								
		CPV-	AT						50270	59326	27020	77170	35296	33718	48780
		CPV-	AT				1300	3562	23227	33399	11500	4000			
	FRI	CPV	AT		1600	9700									
		CPV-	AT				5700	2105	3510	28830	23000	31000	81000		
		CPV-	AT						13100	13988	14012	58200	12940	73740	67100
		CPV-	AT				1580	1334	16385	11569	17400	21900	30571		
	LTA	CPV	AT	2730	1450	5300									
		CPV-	AT				2500	7213	1400	79700	18400	11200	26000		
		CPV-	AT						22000			26800	35100	38371	12400
		CPV-	AT				1160	6486	38332	80300	16400		33195		
	WA	CPV	A+		3000	1590									
		CPV-	A+									46000	24000	22254	16000
		CPV-	A+				3000	9327	39846	33800	40000	18000	22220		
PS				2790	6200	1559	6587	1970	14205	16359	10729	16413	11682	11584	14427
TOTA				3701	3405	3241	2961	5273	16162	18765	12383	17653	14930	13303	16011

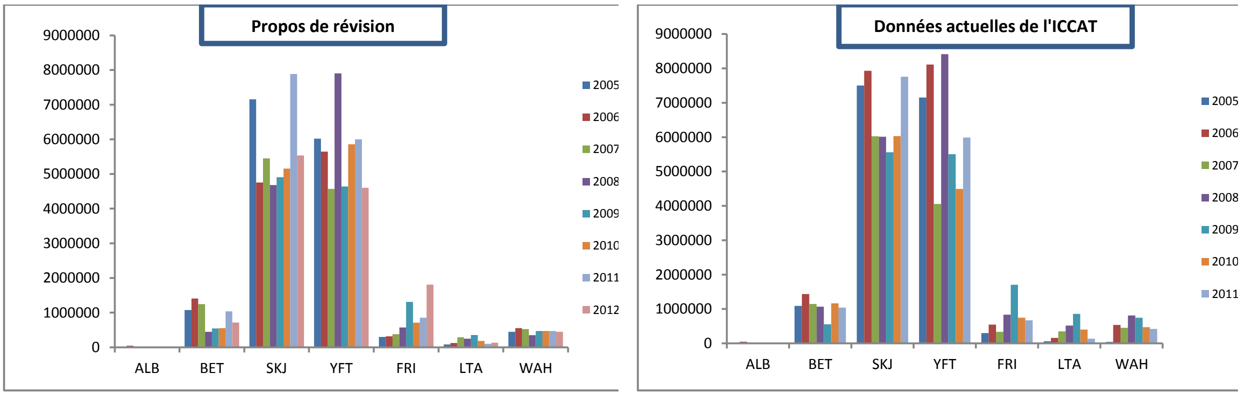

Figure 1. Propos de révision et données actuelles de l'ICCAT (Source : INDP et Calvo Pesca).

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SOME KEY ISSUES IN PEER REVIEWS OF STOCK ASSESSMENTS: LESSONS FROM THE US CENTER OF INDEPENDENT EXPERTS

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SUMMARY

The Center for Independent Experts (CIE) was created to provide independent and timely peer review of the science conducted by the United States National Marine Fisheries Service (NMFS). Of the more than one hundred and fifty reviews conducted by the CIE from its inception in 1999 to the present, the majority of the reviews have pertained to stock assessments; however, many other topics, ranging from population ecology of endangered species to fishery economics, have also been reviewed. The process of selecting reviewers consists of matching the skills required for the review, with the ability of suitable experts subject to constraints set up to avoid picking candidates with potential conflicts of interest. This process is conducted by the CIE independently of the client, the NMFS. We here discuss how lessons learn from operating the CIE can benefit the peer review process for stock assessments in ICCAT. We also provide recommendations on how to modify the ICCAT process to develop an appropriate list of reviewers ensure clarity of reviewer's roles and independence in the reviewer selection process.

RÉSUMÉ

Le Centre pour les experts indépendants (CIE) a été créé pour fournir un examen par des pairs indépendant et opportun des programmes de recherche menés par le National Marine Fisheries Service (NMFS) des États-Unis. Sur plus de 150 examens réalisés par le CIE depuis sa création en 1999 jusqu'à l'heure actuelle, la majorité des examens ont porté sur les évaluations des stocks ; or, de nombreux autres thèmes, passant de l'écologie des populations d'espèces menacées à l'économie des pêcheries, ont également fait l'objet d'examen. Le processus de sélection des examinateurs consiste à faire coïncider les compétences requises pour l'examen avec la capacité d'experts adéquats soumis à des contraintes établies afin d'éviter de sélectionner des candidats qui pourraient avoir des conflits d'intérêts. Ce processus est réalisé par le CIE indépendamment du client, le NMFS. Nous expliquons dans le présent document la façon dont les leçons acquises du fonctionnement du CIE peuvent bénéficier au processus d'examen par les pairs pour les évaluations des stocks au sein de l'ICCAT. Nous formulons aussi des recommandations sur la façon de modifier le processus de l'ICCAT en vue de dresser une liste d'examinateurs appropriée qui garantirait la clarté des rôles et l'indépendance des examinateurs dans le processus de sélection des examinateurs.

RESUMEN

El Centro de Expertos Independientes (CIE) fue creado para proporcionar una revisión por pares independiente y oportuna de los trabajos científicos llevados a cabo por el National Marine Fisheries Service (NMFS) de Estados Unidos. De las más de ciento cincuenta revisiones llevadas a cabo por el CIE desde sus comienzos, en 1999, hasta el presente, la mayoría de las revisiones han estado relacionadas con evaluaciones de stock, sin embargo, se han revisado otros muchos temas, desde la ecología de la población de las especies en peligro hasta la economía pesquera. El proceso de selección de revisores consiste en hacer coincidir las capacidades requeridas para la revisión con las capacidades de expertos adecuados, y está sujeto a las restricciones establecidas para evitar la selección de candidatos con potenciales conflictos de intereses. Este proceso lo realiza el CIE de un modo independiente del cliente, a saber, el NMFS. Aquí se explica cómo puede beneficiarse el proceso de revisión por pares de las evaluaciones de stock en ICCAT de las lecciones aprendidas en las operaciones del CIE. Asimismo, facilitamos recomendaciones sobre cómo modificar el proceso de ICCAT para desarrollar una lista adecuada de revisores, asegurar la claridad en el papel de los revisores y la independencia en el proceso de selección de revisores.

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KEYWORDS

Accuracy, Exploitation, Fishery management, Overfishing, Stock assessment

Introduction

The Center for Independent Experts (CIE), a process funded by the US National Oceanographic and Atmospheric Administration (NOAA) provides peer reviews for the US National Marine Fisheries Service (NMFS. The CIE has provided peer reviews of the most important scientific products of the NMFS over the last 14 years, during which over one hundred and fifty reviews have been conducted on topics ranging from fish stock assessments, protected species management (Brainard et al 2013), socio-economics and many other subjects (Brown et al 2006). The selection process for peer reviewers is driven by two main goals, providing the best quality experts and making sure that they do not have any perceived conflict of interest on the subject matter been reviewed. Because many of the reviews been conducted have direct consequences on the management advice provided by the NMFS the conflict of interest guidelines (Table 1) established by the CIE are more restrictive that those typically used in the peer review journal process (Brown et al 2006). Many of these guidelines refer to having obtained, or planning to obtain any non-competitive funds from NOAA or any other stakeholder of the resources been managed by the NMFS. Given that NOAA is the main source of funding for much of the fishery work in the US this places strong constraints against the selection of US-based fishery scientists.

Although the CIE conducts reviews on a variety of topics, thus uses experts on many different marine science disciplines, many of them relate to fisheries stock assessments. Expertise on stock assessment is therefore the most common skill sought by the CIE and as a result the recruitment and selection of stock assessment experts is a core business of the center. Reviewers hired for such stock assessment reviews are typically contracted for 14 days (2 days travel, 5 days stock assessment meeting, 4 days preparation of review and 3 days report writing). The relative small pool of experts that exists throughout the world combined with the conflict of interest guidelines adopted by the CIE makes the job of recruitment and selection for CIE reviews a difficult one (Brown et al 2006). As the number of stock assessment reviews has continued to increase the list of CIE reviewers has also increased. The worldwide pool of stock assessment scientists is relatively small, therefore the CIE has had to maintain a competitive daily salary rate for its reviewers. Currently this rate is around US$800 a day.

Santiago et al (2013) reviewed the history of independent peer review processes in ICCAT which started with the review of the white marlin assessment in 2002 and briefly describes the processes used by other tuna RFMOs. The most recent peer review was the one for the 2012 white marlin stock assessment (ICCAT 2013, Table 2). The billfish working group and the SCRS discussed some of the issues that the billfish working group faced in taking advantage of the input provided by the review whilst attempting to complete the assessment. These issues (Table 3) were briefly summarized in the SCRS report (ICCAT 2013).

Given these issues the SCRS requested that the ICCAT methods and subcommittee to examine the proposed Terms Of Reference (TOR) for the peer review of the upcoming peer review of the Albacore assessments to be conducted in 2013. This paper presents some of the lessons learned by the CIE to inform the discussions on the TOR for the 2013 peer review of the upcoming albacore assessment.

Reviewer pool

The CIE depends on maintaining a reviewer pool of experts that can be tapped into as reviews are requested. This pool needs to be managed to make sure that the material required to match experts to reviews and evaluate for the possible presence of conflict of interests is kept up to date. Reviewers are included in the pool if they have skills and knowledge of the kind required by the CIE and if they fulfill the conflict of interest guidelines. Once in the pool the reviewers are asked to periodically update their CVs and inform the CIE technical team of any work they do that may change their eligibility because of possible new conflict of interest.

The pool is one of the main assets of the CIE and, as the Center is funded through a competitive process, is actively protected by the current lead institution of the CIE, Northern Taiga Ventures Inc. (NTVI). The reason for this protection is that it is not in the interest of NTVI and its partners, the University of Miami and Oregon State University to share the reviewer pool to possible funding competitors. The CIE, however, has in the past shared some limited information about individual reviewers to other organizations. In addition the names of CIE reviewers are in the public domain, as CIE reports are available through the various parts of NOAA that are clients to the CIE process.

Recommendation: ICCAT may consider, in collaboration with other tuna RFMOs, to develop a reviewer pool for experts with knowledge relevant to tuna stock assessments so as to maintain a list of possible reviewers for tuna assessments.

Selection of reviewers

The process used by the CIE in selecting reviewers (Brown et al 2006) is driven by the need to maintain reviewer selection at an arm length from the client, NOAA. Candidate reviewers are selected by the CIE technical team from the reviewer pool by matching the skills and knowledge required for each review with those of the experts in the pool. After candidates are asked whether they are available for the dates of the review, the CIE technical team produces a short list with the list of names of available candidates. This list is provided to the CIE advisory committee that has the responsibility to select the final candidates. Once informed of the selection NOAA has to accept the reviewers unless it can raise objections to the selection process under some narrow guidelines. These guidelines establish that NOAA can provide the CIE with information they may not have had to re-evaluate their selection specifically in regards to the presence of a possible conflict of interest and/or the appropriateness of the skill set of the reviewer. It is important to note that NOAA can only provide information to the CIE; ultimately it is for the CIE to decide whether the information changes their selection reviewers or not. Under the CIE process NOAA has to accept the final selection of CIE reviewers.

Recommendation: ICCAT may consider, in collaboration with other tuna RFMOs, preparing guidelines for conflict of interest for reviewers and developing a process for reviewer selection that is as removed as possible from ICCAT. A possible solution could be to establish a peer review advisory committee for all RFMOs that would be in charge of selecting reviewers from the short list of reviewers developed by each RFMO. This committee could have representatives of each RFMO. It would be best if the member of each RFMO was asked to recuse herself or himself whenever a selection is conducted for a review for an assessment corresponding to their RFMO.

Reviewer's role

CIE reviewers are charged with producing independent reviews of the scientific material that they have been provided, as documents, presentations at meetings or both. These reviews are meant to reflect exclusively the opinion of each reviewer. The content of the report is explicitly defined in the terms of reference of the review (Tables 2 and 4). In the US CIE reports are public documents, however, the principal clients of the reports are the authors of the scientific material that was reviewed, the scientific advisory committees collating results for fishery managers and the fishery management councils (FMC) themselves (Carmichael and Fenske 2010).

In cases where CIE reviews include participation in an assessment meeting reviewers are often faced with the challenge of contributing to the assessment work being conducted at the meeting to help improve the outputs of the work at the same time as they are preparing a review report. This challenge can be facilitated or hindered by the meeting chair and by the capacity of the assessment teams present at the meeting. The chair needs to avoid allowing the reviewer to be charged with leading components of the analysis, or to allow the reviewer to direct the assessment team's work in such a way that the output of the analysis can be seen to bear the authorship of the reviewer. In some instances, like in the US North Pacific Fishery Management Council, recommendations originating from CIE reviews are only considered for the next assessment cycle so as not to interfere with the current assessment cycle (Carmichael and Fenske 2010).

In the assessment process of the US Fishery Management Councils the units that are charged to produce assessments are required to produce a consensus report which is often the main output of the meetings attended by the CIE reviewers. It is not the CIE reviewer's role to facilitate consensus. Under the current framework of the CIE, reviewers are there to provide individual opinions on the science reviewed. This independent role is not always the role that the Statistics and Scientific Committees of the FMCs would like CIE reviewers to fulfill because the committees' main task is to produce a consensus assessment report (Carmichael and Fenske 2010).

The presence of the CIE reviewer at the meetings, however, will inevitably lead to some unknown contribution from the CIE reviewer to the consensus reports. It is the responsibility of the chair of the assessment meeting to draw the line when necessary to make sure that the contribution of the reviewer to the consensus report does not exceed their independent advisory role in the process.

Most often CIE reviews are conducted on FMCs benchmark assessments and not on simple assessment updates (Crosson 2013). This reflects the higher standards of review that such benchmark assessments have because they are more likely to be associated with management changes than assessment updates. It is NMFS Division of Science and Technology in consultation with the Directors of NMFS Science centers that develops the list of priorities for CIE reviews each year.

CIE reviewers that are stock assessment experts tend to participate in a number of reviews through the years. As a result they acquire experience in the CIE process in a way that helps making their contributions as reviewers to be of high quality and to satisfy the constraints related to independence requirements. Unfortunately, the more reviewers participate in CIE reviews the more they can be seen as loosing independence from the process. This is a direct result of the fact that, unlike other peer review processes, the CIE reviewers are not anonymous. To minimize this, the same reviewer is not used in subsequent assessments of the same stock.

Like in ICCAT, some of the US assessment processes such as the South East Data Assessment and Review process (SEDAR) are conducted over a series of steps. It is clear that each step of the process can benefit from peer review, however, in the US different CIE reviewers are used for each step. The reasoning for this is a desire to avoid reviewers reviewing outputs that have been partially vetted or influenced previously by them. This has a drawback, as reviewers to the assessment part of the process could benefit from having participated in the data preparation process. There is an exception to this in the CIE process. In the STAR process, which pertains to NW Pacific assessments, assessments are conducted in a bi-annual cycle so that every two years a large number of stocks are assessed through a series of assessment meetings. The CIE provides independent reviewers for each assessment; however, it also provides a “primary reviewer” who attends all the assessments in that year. This primary reviewer is designated to provide consistency of review across assessments and also facilitate the communication of the review of assessment results to the North Pacific Fishery Management Council. The reviewer’s role is therefore distinct from that of the other CIE reviewers present at the assessment meeting (Table 2). The primary reviewer is charged to present to the North Pacific Fishery Management Council at the end of the assessment year, a consolidated presentation of the conclusions reached by all reviewers and of the review process.

Recommendation. ICCAT may consider, to define guidelines for individual reviewer’s participation in assessments:

- *the same reviewer should not participate in subsequent assessments of the same stock*
- *the same reviewer should not participate in data preparation meetings and assessment meetings for the same stock*

In summary, through its history, the CIE has faced many of the challenges that ICCAT is facing to design, maintain an implement a peer review system that improves the quality of scientific outputs that support fisheries management (Carmichael and Fenske 2010, Cordue 2007) and marine ecosystem management (Brainard et al 2013). The CIE has adopted a set of operating guidelines that match the specific goals of the NMFS quality control program. Some of such guidelines may be appropriate for ICCAT, but others may not. In designing such guidelines ICCAT has to define how it balances the competing objectives of providing independent and efficient reviews.

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Table 1. Conflict of interest guidelines for the US Center of Independent Experts.

To maintain the highest level of independence in the peer review process, the CIE utilizes a rigorous process to ensure that no participant has any conflicts that would preclude the participant's effectiveness, either real or perceived.

Candidates are selected only after the CIE Coordination Team has ascertained that the candidates possess the necessary expertise, the preferred experience, and the demonstrated ability to address the issues pertinent to the review. Then, each candidate is provided with a standard conflict of interest form. The candidate must expert advice free from the influence of Government managers, the fishing industry, or any other interest group. Any candidate who has conducted any of the following is considered ineligible as a participant in a CIE review:

- Received in the past (1-2 years) substantial funds from industry or environmental groups with vested interests in resources for which NMFS has stewardship responsibilities;
- Received in the recent past substantial funds from NMFS via a sole-source contracts; or
- A history of an advocacy role for a specific viewpoint.

Table 2. Statement of work and format of report for CIE review of assessment of Stock Assessment of Striped Marlin.

Statement of work

1. Review of the assessment methods: determine if they are reliable, properly applied, and adequate and appropriate for the species, fisheries, and available data.
2. Evaluate the assessment model configuration, assumptions, and input data and parameters (fishery, life history, and spawner recruit relationships): determine if data are properly used, input parameters seem reasonable, models are appropriately configured, assumptions are reasonably satisfied, and primary sources of uncertainty accounted for.
3. Comment on the proposed population benchmarks and management parameters (e.g., MSY, Fmsy, Bmsy, MSST, MFMT); if necessary, recommended values for alternative management benchmarks (or appropriate proxies) and clear statements of stock status.
4. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status.
5. Suggest research priorities to improve our understanding of essential population and fishery dynamics necessary to formulate best management practices.

Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.
2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.
3. The reviewer report shall include the following appendices:

Appendix 1. Bibliography of materials provided for review.
Appendix 2. A copy of the CIE Statement of Work.

Table 3. Unresolved issues about ICCAT peer review system identified by the SCRS (ICCAT 2013).

Issue	Quotation from ICCAT 2013
Need for consistency in quality of the review	**"…**inconsistence in advice:…. where you get different peer reviewers from one assessment to another."
Dual Role of experts as reviewers and analysts	**"…**A potential problem was that when a reviewer actively participates in a meeting, he/she will also have part ownership of the results from the meeting… For example by participating in a data prep meeting they will have had responsibility for inputs into the assessment."
Reviewers becoming part authors of the outputs in a multistage assessment process	"It was agreed that if there is a capacity problem then we there is a need to strengthen the stock assessment teams and not rely upon a peer reviewer to provide missing expertise."

Table 4. Extract of terms of reference for primary CIE reviewer of the STAR process in 2013.

Requirements for CIE Reviewer: One CIE reviewer is requested to participate in all 2013 STAR panel meetings to provide scientific review and ensure consistency of analytical approaches among assessments, as appropriate. The reviewer shall be an active and engaged participant throughout panel discussions and able to voice concerns, suggestions, and improvements while respectfully interacting with other review panel members, advisors, and stock assessment technical teams. The CIE reviewer shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. The CIE reviewer shall have excellent communication skills in addition to working knowledge and recent experience in fish population dynamics, with experience in the integrated analysis modeling approach, using age-and size-structured models, use of MCMC to develop confidence intervals, and use of Generalized Linear Models in stock assessment models. The CIE reviewer's duties shall not exceed a maximum of 14 days for each panel meeting review to complete all work tasks of the peer review described herein.

Statement of Tasks: The CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks prior to the scheduled peer review meetings, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewer the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. The CIE reviewer is responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewer shall read all documents in preparation for the peer review. Documents to be provided to the CIE reviewer prior to the STAR Panel meeting include:

- The current draft stock assessment reports;
- Previous stock assessments and STAR Panel reports for the assessments to be reviewed;
- The Pacific Fishery Management Council's Scientific and Statistical Committee's Terms of Reference for Stock Assessments and STAR Panel Reviews;
- Stock Synthesis (SS) Documentation
- Additional supporting documents as available.
- An electronic copy of the data, the parameters, and the model used for the assessments (if requested by reviewer).

Panel Review Meeting: The CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator. The CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewer as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: The CIE reviewer shall complete an independent peer review report in accordance with the SoW. The CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. The CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Other Tasks – Contribution to Summary Report: The CIE reviewer may assist the Chair of the panel review meeting with contributions to the Summary Report, based on the terms of reference of the review. The CIE reviewer is not required to reach a consensus, and should provide a brief summary of the reviewer's views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the Schedule of Milestones and Deliverables.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Participate during the panel review meetings as scheduled between 22 April and 23 September, 2013 as specified herein, and conducts an independent peer review in accordance with the ToRs (Annex 2).
3) No later than XX, the CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and to Dr. David Die, CIE Regional Coordinator, via email to ddie@rsmas.miami.edu.
4) Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2.

ICONOGRAPHY OF TUNA TRAPS: THE DISCOVERY OF THE OLDEST RECORDED PRINTED IMAGE OF A TUNA TRAP

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SUMMARY

The iconography of tuna traps is an essential element for providing better knowledge of this ancient fishing technique. Images from the earliest period are not very common and printed images from the XVI century are extremely rare. Since the publication of a comprehensive review in 2012 (SCRS/2012/036) an earlier engraving has been found. This latest finding is particularly relevant not only because it is the first known printed image of a tuna trap but also because of the artistic importance of its author, Adamo Scultori. This masterpiece engraving was printed in an uncertain date between 1563 and 1565. This paper provides details about this specific engraving as well as its historical and artistic context.

RÉSUMÉ

L'iconographie des madragues thonières est un élément essentiel pour fournir une meilleure connaissance de cette ancienne technique de pêche. Les images de la toute première période sont peu fréquentes et les impressions du XVIe siècle sont extrêmement rares. Depuis la publication d'une étude exhaustive en 2012 (SCRS/2012/036), une gravure plus ancienne a été découverte. Cette toute dernière découverte est particulièrement importante car il s'agit non seulement de la première impression connue d'une madrague thonière mais aussi en raison de l'importance artistique de son auteur, Adamo Scultori. Ce chef-d'œuvre d'impression a été réalisé à une date incertaine, entre 1563 et 1565. Le présent document fournit des informations détaillées sur cette gravure spécifique ainsi que sur son contexte historique et artistique.

RESUMEN

La iconografía de las almadrabas de atún es un elemento esencial para obtener mejores conocimientos de esta antigua técnica de pesca. Las imágenes del periodo inicial no son muy comunes y las imágenes impresas del siglo XVI son muy escasas. Desde la publicación de una revisión exhaustiva en 2012 (SCRS/2012/036) se ha encontrado un grabado anterior. Este último hallazgo reviste especial importancia, no sólo porque es la primera imagen impresa conocida de una almadraba de túnidos sino también por la importancia artística de su autor: Adamo Scultori. Este grabado, que es una auténtica obra de arte, se imprimió en una fecha desconocida entre 1563 y 1565. En este documento se proporciona información detallada sobre este grabado específico, así como sobre su contexto histórico y artístico.

KEYWORDS

Trap fishery, bluefin tuna, ancient seafood industry, Mediterranean Sea, fishing gear, historical images, engravings

1. Introduction

The review of the iconography on tuna traps presented in 2011 (Di Natale, 2012a) at the ICCAT-GBYP Symposium on Trap Fishery for Bluefin Tuna (Tanger, Morocco, May 23 to 25, 2011 (Anon., 2012) reported most of the known ancient images of this age-old industrial fishery activity.

At that time, the oldest pinted images of the trap fishery were considered to be the marvelous etchings of Georg (Joris) Hoefnagel, who engraved the views of many Spanish cities in the volumes of the world famous "*Civitates Orbis Terrarum"* (1572-1617), by George Braun and Franz Hogenberg. The first etching shows a beach seine fishery in Cadiz (published in the first volume in 1572) and the second clearly shows the bluefin tuna fishery in

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Conil (published in the second volume in 1575). It is not clear if the beach seine in the first etching of Cadiz was used for bluefin tuna because, apparently, it is a common seine used for other smaller species and, furthermore, the position along the coast is different from the tuna trap factory position. Another larger etching, illustrating the bluefin tuna fishery in Cadiz in a more detailed way, was published in the same volumes. However, it is not clear if this was included in some copies of the first volume (1572) or if it was added only to the second edition in 1598.

For many decades, these images were considered the first printed images of a tuna trap and they both illustrated beach seines, one of the types of tuna traps used in the Mediterranean Sea since at least the Phoenician times, VII centuries b.C.

The purpose of this paper is to provide an update of the very first part of the tuna trap iconography, after the discovery of a very rare engraving, which was printed possibly about a decade before those published by Braun and Hogenberg.

2. Background history of the first tuna trap engraving

The tuna trap engraving recently discovered was made by Adamo Scultori, also known as Adamo (or Adam) Ghisi, who was born in Mantova (Italy) c.a. 1530. His father, Giovanni Battista Scultori, and his sister, Diana Scultori, were both very well-known artists and fine engravers. The reason he and his sister are sometimes referred to as Ghisi is because of the misinterpretation of Vasari's text (1568), who considered the three artists belonging to the Scultori family as "close" to Giorgio Ghisi, a famous engraver and artist also from Mantova, where he was born in 1520. Ghisi was considered to have learned engraving from Giovanni Battista Scultori. After Vasari's book, several authors followed this erroneous interpretation and created confusion about the name. Furthermore, Ghisi's earliest works were engravings after the famous artist Giulio Romano and this, as we will see, perhaps added some misinterpretation about Adamo Scultori. Precise, detailed data about Adamo Scultori and his artistic works are reported by Bellini (1991).

Giulio Romano (Rome, 1499), also known as Iulius de Pippis de Ianutiis, Giulio Pippi or Jannuzzi, was an Italian painter and architect, pupil of the archi-famous artist Raffaello Sanzio. He worked on many frescos of the Vatican Loggias as a young assistant of Raphael and then, as he started to gain reputation decorated many important places and buildings. King Charles V summoned him to Mantova to carry out the work on many important buildings and decorations. He also travelled to and worked in France. Romano died in Mantova in 1546.

Giulio Romano, who is considered one of the great masters of Italian painting in the XVI century, was also the author of the acknowledged masterpiece of architecture and fresco painting in Mantova, the suburban Palazzo Te, with its famous illusionistic frescos. This magnificient building (**Figure 1**) was constructed from 1524 to 1534 for Federico II Gonzaga, Marquess of Mantova.

Inside the Palazzo Te many frescos remain the most remarkable feature of this magnificient building. One of the rooms, the Winds Room ("Sala dei Venti") or Zodiac Room ("Sala dello Zodiaco") has a very elaborate floor and the roof is decorated by many frescos and sculptures, dominated by the central figure of a mask creating the wind. The room was decorated in 1527 and 1528 by the sculptor Nicolò da Milano, the plasterer Andrea di Pezzi and the painters Anselmo Guazzi, Agostino da Mozzanica, Benedetto Pagni and Girolamo da Treviso. Close to one of the doors, just over the fireplace, and below the Fish constellation, there is a circular fresco surrounded by a plaster wreath depicting a fishing scene.

According to the current interpretations of this drawing, based on the opinion of Marcus Manilius, a Latin poet who wrote the famous poem "*Astronomica*" in the 10^{th} a.C., with many references to the origin and meaning of each constellation, particularly in its Liber V concerning the extra-zodiacal signs (Gombrich, 1950; Bellini, 1991; Manilio re-ed., 1996-2001), those who are born in the last phase of the Fish constellation are destined to be fishermen targeting big fish. It is the reason why the fresco showing this fishery was situated in this position within the Winds Room.

This particular fresco in the Winds Room of Palazzo Te in Mantova is the first engraving depicting a tuna trap.

3. The tuna trap engraving by Adamo Scultori

The original preparatory design of the fresco depicting a fishery scene was made by Giulio Romano, possibly in 1526 or 1527. The drawing (**Figure 2**) is now kept in the collections of the Louvre Museum (inv. No. 3560) in Paris and it is described as “Capture of big fish”.

The fresco painting showing the same fishery scene in the Winds Room at Palazzo Te in Mantova (Italy) (**Figure 3**) was made by Girolamo da Treviso. This famous artist also known as Girolamo di Tommaso da Treviso the Younger and Girolamo Trevigi, was an Italian Renaissance painter. Born in Treviso in 1508, he flourished under the artistic influence of various painters, like Pennacchi, Romano and Raphael. He worked in Bologna, Genova, Faenza, Trento and for Palazzo Te in Mantova. He also travelled to England to work as a military engineer and painter for Henry VIII. While working for Henry VIII he was killed by a cannon shot during the siege of Boulogne-sur-Mer in 1544. This fresco painting is considered to be related to astrology, because the image represents fish and for the general context of other frescos in the same room.

The engraving of the same drawing made by Giulio Romano and the fresco painting made by Girolamo da Treviso was etched by Adamo Scultori, possibly in the period 1563-1565. A more complete description is provided by Bellini (1991), who wrote an exhaustive book on both Adamo and Diana Scultori and who kindly provided more details on this specific engraving. The original plate of this engraving, carved by a graver, is kept at the Italian National Calcography in Rome (inventory no. 651).

It is not clear if this engraving was originally included in a booklet or if it was produced separately as such. This engraving by Scultori was described by several authors dealing with artistic or engraving masterpieces (Huber, 1797; Von Bartsch, 1813; D’Arco, 1837; Le Blanc, 1856; Ferrara *et Al.*, 1977; Massari, 1980; Strauss *et Al.*, 1986; Bellini, 1991). Even though the date is also not available, according to Bellini, the style of the monogram on the engraving, a letter “A” having two convergent pipes (**Figure 4**), situates this engraving in the third phase of the Mantuan period of Adamo Scultori, from 1563 to 1565. According to the very precise details reported by Bellini (1991), the engraving described in this work is from a second printing, because the original support had some minor damage on the lower left corner, close to the monogram. These dates are well before the engravings of the tuna fishery made by Braun and Hogenberg (1572-1575) and then the engraving made by Adamo Scultori (**Figure 5**) is the first one ever printed.

The engraving measures 210x320 mm in size and it is very well preserved. It belonged to a private Spanish collector in Barcelona, who sold this and other engraved masterpieces to a local antiquarian who then put them on the market. Copies of this extremely rare engraving are in the collections of the Vatican Museums in Rome, of Castello Sforzesco in Milano (Engravings collection “Achille Bertarelli”), of the British Museum in London, of the Biblioteque Nationale in Paris, in Dusseldorf, Hamburg, Wien, Amsterdam, Berlin, Coburg, Bassano del Grappa, Bergamo, Bologna, Brescia, Florence (both at the Biblioteca Marciana and the Uffizi Museum), Parma, Roma and Siena (Bellini, 1991).

4. Discussion

There are several reasons explaining why this important engraving was never mentioned in any previous paper concerning the tuna trap fishery and its huge iconography.

The basic one is very simple: the art experts are not fishery experts and they are not necessarily knowledgeable about the various fishing gears. This image, along with the original preparatory drawing and the fresco, have been always classified as “Capture of big fish” and never as “tuna trap fishing”, simply because none of the experts who examined this image was aware that it was clearly representing a “matanza” in a tuna trap. At the same time, fishery experts are not necessarily art experts and then their knowledge of some artistic products might be partial. Furthermore, sometimes this engraving was classified as “Capture of a marine monster”, because the images of large fish and tunas in the XVI centuries, when they were depicted by artists not having direct knowledge of the individual species, were made using a lot of fantasy, mixing-up parts of various marine species.

From a practical point of view, an image classified as such never entered the circuit of the tuna trap experts and then it was simply ignored. No reference to this image exists in any of the more than 1,200 references concerning the tuna trap fishery (Di Natale, 2012b).

As a matter of fact, the historical value of this engraving is extremely relevant, specifically because it shows very clearly that the traditional trap fishery was carried out with set traps even at that time, as reported in several books (Di Natale, 2012b). This fact demonstrates that several types of tuna traps were active at the same time in various parts of the Mediterranean Sea and the eastern Atlantic, because the etching by Braun and Hogenberg clearly depict beach seines.

The engraving made by Adamo Scultori, based on the preparatory drawing by Giulio Romano and the later fresco painting by Girolamo da Treviso, very clearly shows the typical final phase ("matanza" or "mattanza") of tuna fishing by a set trap, with three vessels hauling the net with several fish inside and fishermen with harpoons and claws. There is no doubt about the fact that this was a tuna trap.

Later, after the discovery of the real meaning of the engraving and before the preparatory work for this paper, the author investigated if it was possible to find out from which area Giulio Romano had made the image. After investigating all Giulio Romano's known movements and travel during his life, only one coastal place was located where it was possible to find his tracks. As a matter of fact, the bishop of Genova contracted Giulio Romano in 1523 to depict an altarpiece for the Abbey of Santo Stefano in Genova. This painting still exists in the same Abbey. Furthermore, after the sack of Rome carried out by Charles V in 1527 and the following diaspora of all artists working with Raphael, one of Romano's colleagues and close friends, the painter and artist Perin del Vaga (also known as Pietro Bonaccorsi) moved to Genova in the same year, where he worked on the frescos of Palazzo Doria until 1538.

In the early XVI century there were three tuna traps set in the area close to Genova (Pavesi, 1889; Parona, 1919; Mariotti, 2003), one in Camogli (a small tuna trap called "tonnarella", possibly active since at least 1383 and well documented since the beginning of 1500, when the high income from this trap financially supported the development of the harbour in Camogli) (Cattaneo Vietti and Bova, 2009), another in Santa Margherita Ligure (very close to Camogli), and a third one in Monterosso. These three traps were active up to the beginning of the XX century, while only one (Camogli) still exists. It is very possible that Giulio Romano obtained, directly or indirectly, information about the Ligurian tuna trap fishery in Genova before making the original preparatory design for the fresco and the dates are in agreement with this hypothesis.

Consequently, even if the image does not provide any specific information about a location, it is now possible to ascertain that it was based on the tuna trap activity carried out in one of the Ligurian traps, possibly the one in Camogli.

Another famous engraving on the tuna trap fishery in Italy was published a few years after, etched by Adrian Colaert, on a subject by Jan Van der Straet (more commonly known as Johannes Stradanus), for the second edition of "*Venationes Ferarum, Avium, Piscium, pugnae bestiarorum et mutuae bestiarum*", published in Antwerp, Belgium, by Philipp Galle. The first edition (1578) had the same plates but without the progressive numbers, while the second edition was possibly published in 1584. This image shows a bluefin tuna fishery in Naples (Italy), with tunas kept by the net, with the support of small boats and then harpooned (Di Natale, 2012). It is possible that that etching depicted a small coastal tuna trap ("tonnarella") targeting juvenile bluefin tuna, a fishery active in the area south of Naples until about 1980.

Those two engravings, which were published within a short range of years, support the hypothesis that in the XVI century set traps were more common in Italy, while beach seines were more used in Spain.

5. Acknowledgments

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However, this work could not have been possible without the engraving itself, which was kindly provided by Albert Marti Palau, who discovered it.

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Figure 1. Aerial wiew of Palazzo Te in the suburbs of Mantova (Italy) (image from: http://www.lecicloviedelpo.movimentolento.it/).

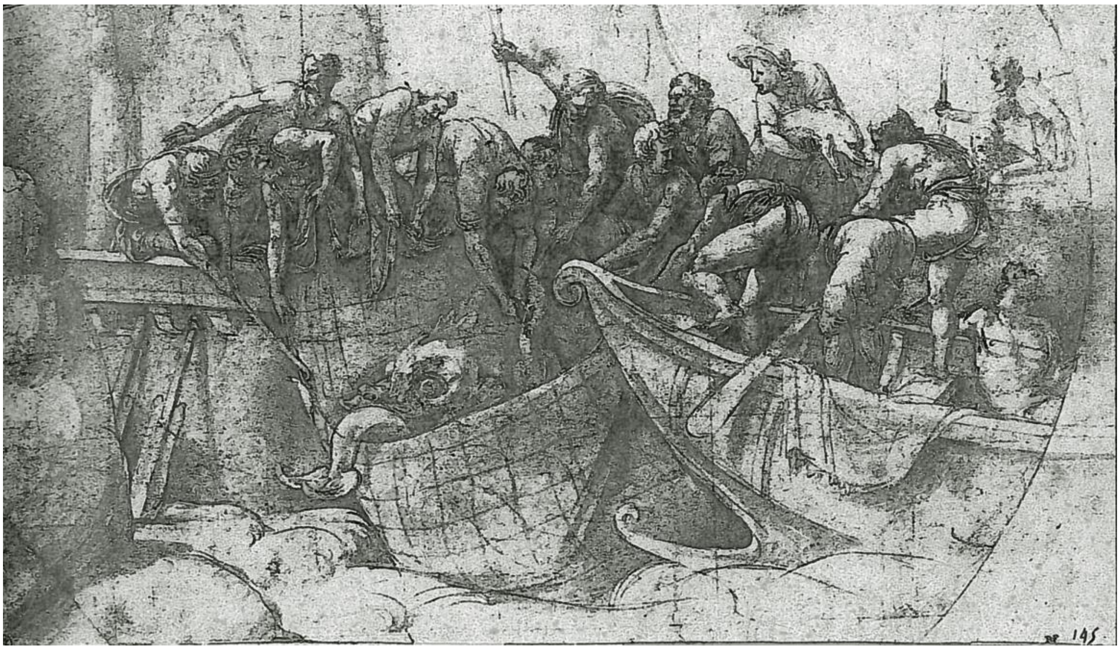

Figure 2. The original drawing made by Giulio Romano for the fresco in the Winds Room at Palazzo Te in Mantova (Italy) (from Bellini, 1991). The drawing is now in the Museum du Louvre in Paris.

Figure 3. The fresco painting made by Girolamo da Treviso in 1527-1528 in the Winds Room ("Sala dei Venti" in Palazzo Te in Mantova (Italy).

Figure 4. Enlarged image of the monogram of the artist Adamo Scultory in the lower left corner of the engraving showing the tuna trap fishery.

Figure 5. The very first engraving of a tuna trap fishery, made by Adriano Scultori possibly in 1563-1565, in Mantova (Italy).

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THE ANCIENT DISTRIBUTION OF BLUEFIN TUNA FISHERY: HOW COINS CAN IMPROVE OUR KNOWLEDGE

A. Di Natale[1]

SUMMARY

*The bluefin tuna (*Thunnus thynnus*) trap fishery was an industrial activity since at least the Phoenician times. Evidences of tuna salt factories are very well known in many places, showing the ancient distribution of bluefin tuna. Ancient coins are able to confirm the economic relevance of bluefin tuna in various places, not necessarily the same where tuna factories were located. This paper is a first tentative of assembling most of the information available for better understanding the ancient distribution of bluefin tuna between VI centuries b.C. and V centuries a.C. The difference between the distribution in classic historical times and the current distribution of this species is very evident for the Black Sea area.*

RÉSUMÉ

La pêcherie de madragues de thon rouge (Thunnus thynnus) *est une activité industrielle remontant au moins à l'époque phénicienne. On peut encore rencontrer des vestiges d'installations de salaison du thon en de nombreux endroits, indiquant l'ancienne zone de répartition du thon rouge. Des pièces de monnaie anciennes peuvent confirmer l'importance économique du thon rouge en divers endroits, pas nécessairement sur les lieux où se trouvaient les installations de salaison du thon. Le présent document tente pour la première fois de rassembler la plupart des informations disponibles afin de mieux appréhender l'ancienne distribution du thon rouge entre le 6e siècle avant J-C et le 5e siècle après J-C. La différence entre la distribution au cours des époques historiques classiques et l'actuelle distribution de cette espèce est très manifeste pour la zone de la mer Noire.*

RESUMEN

*La pesquería de almadrabas de atún rojo (*Thunnus thynnus*) ha sido una actividad industrial desde por lo menos los tiempos de los fenicios. Las pruebas de factorías de salazón de atún son muy conocidas en muchos lugares, lo que muestra la antigua distribución del atún rojo. Las monedas antiguas confirman la importancia económica del atún rojo en varios lugares, no necesariamente los mismos en los que estaban situadas las factorías de atún. Este documento es el primer intento de unir la mayor parte de la información disponible para entender mejor la antigua distribución del atún rojo entre los siglos VI a C. y V d. C. La diferencia entre la distribución en tiempos históricos clásicos y la distribución actual de esta especie es muy evidente en la zona del mar Negro.*

KEYWORDS

Trap fishery, Ancient industry, Bluefin tuna, Historical fish distribution, Atlantic Ocean, Mediterranean Sea, Black Sea, Fish industry, Ancient coins

1. Foreword

Bluefin tuna fishery is the most ancient fishing industry of the world (Di Natale, 2012a, 2012b). Knowing the evolution of a fishery, possibly starting from the first time the pristine fish population was exploited by man, is usally one of the dreams and target of all fishery scientists. This is usually almost impossible, because most of the fisheries have very little details about their very early beginning and several have no written stories.

Maybe the bluefin tuna fishery is an exceptional case, because it is one of the few for which we can find tracks and evidences, by using several tools (Herodotus, V b.C.; Eschilo, 472 b.C.; Philostratus de Lemnos, III b.C.; Solinus, III b.C.; Theocritus, III b.C.; Ulpianus, III b.C.; Aelianus, II a.C.; Ataeneus di Naucratis, II a.C.;

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Polibius, 220-146 b.C.; Oppianus, 177 b.C.; Strabonius, I b.C.; Plinius, 65 a.C.; Giovio, 1524; Esopo, 1592; Aristoteles, 1635; Cirino, 1653; Smidth, 1876; Adams, 1883; Basile, 1899; Mila y Pinell, 1902; Radclife, 1921; Cornwin, 1929; Thomazi, 1947; Moreno Páramo & Abad Casal, 1972; Dumont, 1976-77, 1981; Manfredi, 1987; Doumenge, 1988, 1999; Mastromarco, 1988; Santos Castroviejo, 1990; Merino, 1991; Powell, 1996; Muñoz Vincente & de Frutos Reyes, 1999; VV.AA., 2001. 2004, 2006; Torrente, 2002; Bekker-Nielsen, 2005; Levine, 2006; Pepe, 2006; Morales-Muñiz & Roselló-Izquierdo, 2008; Bernard Casasola, 2009, 2011b; Bekker-Nielsen & Bernal Casasola, 2010; Vargas *et Al*., 2010; Anon., 2012; . This is particularly true for the trap fishery, certainly the first industrial fishery activity since very ancient times.

While bluefin tuna fishery was carried oud with hand lines in several parts of the Mediterranean Sea, the Black Sea and the Eastern Atlantic since prehistorical times (the engravings on the rocky walls of the Genoese's Cave in the isle of Levanzo, Egadi Islands, W. Sicily, Italy, are dated about 9,200 years b.C.), and while Aegean tuna bones in some locations are about from the same period, these individual fishing activities can be considered as having a very limited impact on the bluefin tuna population, even if it is evident that since these remote times, bluefin tuna was regularly a common food resource for the Mediterranean inhabitants and a basic component in their diet (Curtis, 1991; Dumont, 1981; Powell, 1996), at least for those living close to the coasts. In some cases, like in the Aegean area, the bluefin tuna was representing about 80% of the fish food in prehistoric times (Powell, 1966).

The organised exploitation of bluefin tuna begun when somebody invented the tuna traps and the fish factories linked to them. According to our current knowledge and to the recent reviews of literature and iconography of this ancient fishery (Anonimous, 2012; Di Natale, 2012a, Di Natale 2012b), the Phoenicians started this industrial activity, both in the Mediterranean Sea and in the Atlantic, followed by the Greek in the Black Sea and in the Aegean Sea and then by the Romans in many other places in the Mediterranean Sea and in the Atlantic Spanish areas close to Gibraltar.

Besides of very few precise ancient documents, fish salting plants and factories and local coins are among the very limited evidences we can use for mapping the most important sites related to tuna fishery in classical historical times.

The objective of this work is not to revise all papers and evidences concerning the archaeological evidences of fish salting factories, coins or amphores, a work requiring a deep knowledge in other scientific fields and an important dedicated working time, but to have a general idea for SCRS purposes, based of the most known data sources, about the geographical distribution of the historical evidences of the main places where tuna fishery was important in classical historical times, usually between VI b.C. and V a.C. For these reasons this work is certainly incomplete and can be considered as preliminary.

2. Fish salting factories

The distribution of ancient fish factories, which were necessary for salting the fish and for producing the famous *garum* sauce, is relatively well-known and it is not the target of this paper, because a complete revision of the current archaeological knowledge will require a long time for studying all archaeological evidences and the many papers existing on them (Gogarín, 1930; Bacci, 1982, 1984; Purpura, 1982, 1989, 1992; Molina & Jiménez, 1983; Bufardieci, 1985; Aubert, 1987; Edmondson, 1987, 1990; Curtis, 1988; Santos Castroviejo, 1990; Basile, 1992; Hurst, 1994; Cernigliani, 1995; Muñoz Vincente & de Frutos Reyes, 1999, 2004; Atanasio, 2001; VV.AA., 2001, 2004; Ètienne & Mayet, 2002; Curtis, 2005; Azcoyta, 2007a; Fernandez Gómez *et Al*., 2007; Fernández Pérez, s.d.; Ruíz Bravo, 2007; Bernard Casasola, 2011a; Habibi, 2011) . Only same papers clearly particularly describe fish salting plants, while descriptions are more often incorporated in general descriptions of several archaeological coastal sites.

Fish salting factories are easily detectable if ruins are still readable in their general aspect. As a matter of fact, usually they are represented by series of small or large tanks or pools (squared or circular), made by various materials able to keep liquids. Fish was also kept in very large cound-shaped amphoras, called *dolia* (singular *dolium*), kept both out of the soil or partly buried.

The location of these fish salting factories is usually and logically close to "salinas", coastal areas where sea salt was produced in large quantities, because the marine salt was the essential component of this industrial production (Boscarino, 1963-64; Purpura, 1982, 1989; Manzi-Giusi *et Al*., 1986; Ríos Jiménez, 1999; García Vargas, 2001; Mederos Martín & Escribano Cobo, 2004; Pérez Gomez *et Al*., 2007; García Vargas & Florido del

Corral, 2010; Casano del Puglia, 2011; Soler Cervantes, 2011). These fish salting factories were called *taricheiai* by Greeks and *cetaria* by Romans (Campos *et Al*., 1999) and some of them were quite big, like the one in Baelo Claudia in Southern Spain (Azcoytia, 2008) or Lixus in Morocco (Azcoytia, 2009). Some famous fish factories, noticed in ancient papers, are still to be uncovered, like the one in Pompey, close to Naples, buried by the eruption of the Vesuvio volcano. It is possible that it was located outside the ancient town, because the production of *garum* created such unpleasant smells that factories were generally relegated to the outskirts of cities.

At the end of the production process, salted tuna and *garum* sauce were usually transported inside terracotta anphores (Desse-Berset, 1993) and most models, especially made for transporting *garum*, are very well known, helping in detecting the places where factories were settled (i.e.: Dressel F form, Dressel H form, Dressel 18, Mama C1b, Mama C2c, Mama C2c, etc.). For the purpose of this paper, the distribution of these amphores was not taken into account.

The *garum* souce was largely used in ancient times and it was made by collecting the liquid coming from the pools where fish meat was preserved under salt during its "maturation" (Mattioli, 1568; Smidth, 1876; Ponsich & Tarradel, 1965, 1988; Curtis, 1991; Ben Lazreg *et Al*., 1995; Desse-Berset & Desse, 2000; Morales-Muñiz et Al., 2004; Azcoytia, 2007b; Bernard Casasola, 2011a). It was used for increasing the taste of various foods and dishes, particularly by the Romans. The best and more expensive *garum* in the ancient Greek markets was the *arimàtion*, made by salting the stomac, the intestine and the blood of bluefin tunas. The Romans seems preferred the *garum sociorum*, produced in Cartagena and Gadez (Cadiz). It was also called *liquamen*, which is considered a synonymous at least for a number of years. Garum sauce was sometimes produced also with other pelagic fish than bluefin tuna, such as anchovies, sardines, bogues and mackerels. The sediment or sludge that remained was called *allec*.

Garum sauce was very nutritious, retaining a high amount of proteins, amino acids, minerals and B vitamins; *Garum* was expecially rich in glutamic acid, having the same characteristics of the modern monosodium glutamate, a flavor enhancer because it balances, blends and rounds the total perception of other tastes.

Garum sauce is still produced in a very few places around the world. One is still in the Mediterranean, but it has a more delicate taste for fitting the moder taste and then is made using anchovies instead of bluefin tuna[2]; it is produced in Cetara, a small town close to Salerno, in S. Italy. Other famous fish sauces similar to *garum* are the Vietnamese *nuoc-mam* and the Thai *nuoc-cham*, the Japaneses *ishiru*, *shottsuru* and *ikanago shoyu*, and the Korean *aekjeot* or *jeotgal*. No one of these fish sauces similar to the ancient *garum* is made by using tuna.

According to some literary evidences, it seems the one of the most apreciated *garum* was also including some herbs in the salting process and, among these herbs, the most reputed and expensive was the *Silphium*. *Silphium* is an extinct herb that grew near Cyrene (E. Libya), a Greek colony established by Sparta. The height of *Silphium* production was between VII and II centuries b.C. The Greeks did try to transplant and grow it in other areas, but not successfully. It was practically extinct by the 1st century a.C. due to overharvesting. It is not entirely clear what plant it was; it seems to have been like that of fennel. This ancient and extinct vegetable species is not at all related with the current plants of the genus *Silphium*, mostly distributed in North America.

The fish salting factories in classic historical times were located in all parts of the Mediterranean Sea, in the Eastern Atlantic close the Strait of Gibraltar, in the Black Sea and even in the Azov Sea (Morales *et Al*., 2007). In some cases it was possible to have a precise location (**Figure 1**), while in other cases there are historical evidences of *garum* production in some areas (i.e.: like in some Greek areas and even in the Canary isles) but without precise locations.

Some of these salt fish and *garum* factories were active since V b.C., but most of them were built in III b.C.; some were active up to V a.C., except the factory in Porto Palo (S. Sicily) which was still active in the X century. Obviously, each site has its own history.

Figure 1 shows the location of the most known fish salting plants in classical history, but it is possible that several other factories were present in other ancient locations.

The most reputed and famous *garum* factories were Byzantion (now Istanbul, Turkey) (Tekin, 2000), Cyzicus (now Aydıncıķ, Turkey), Barbate, Ayamonte and Baelo Claudia (Spain) (**Figure 2**) (Sillières, 1995; Morales-

[2] The name of this *garum*-like sauce is "colatura di alici".

Muñiz & Roselló-Izquierdo, 2007), Lixus (Atlantic Morocco) (**Figure 3**), Cyrene and Apollonia (E. Libya), Leptis Magna (close to Homs, Libya), Neapoli (now Nabeul, Tunisia), Cartagine (close to Tunis, Tunisia), Tipaza (Algeria) (**Figure 4**), Pompei and Gela (Italy).

A particular importance is given to the fish salting factories of Pontikapaion, active in the Azov Sea from III b.C. to IV a.C. (Morales *et Al*., 2007), and Chersonesus, active in Crimea from I b.C. to III a.C., because these two factories are the only proofs of the bluefin tuna presence in these NE areas of the Black Sea region.

3. Coins with tuna images

Another evidence of the commercial and economic relevance of the bluefin tuna fishery or industry in classical historical times is provided by the coins. As a matter of fact, antique coins were characterised by power or religious images (kings, emperors, gods or divinities) or by images representing symbols or locally relevant productions.

Coins with images of tunas were present in many archaeological sites and they are well known by archaeologist, historicians and coins collectors (Savas Lenger, s.d.; García Bellido, 1991; Mederos Martín, 2007; Callegarin & Rippollés, 2010; Marín Martínez, 2011; Ripollés, 2013). In some coins the tunas are very visible while in others are parts or components of other images and then their detection is not always easy. Sometimes, fish images are not clearly showing a bluefin tuna and in these cases it is necessary to examine various coins minted in the same place over the time for better defining the species.

The persistence of tuna images on coins from the same mint or place over centuries or for an extended period of years is considered a good evidence of the continuation of the economic relevance of the tuna fishing and industry activities in that particular place.

Coins with tunas were not very common in the classical historical times and their distribution (**Figure 5**) is partly different and more limited of that of the fish salting factories in the same classical historical times. Furthermore, in some cases, coins with tunas were mint in ancient inland towns, close to rivers or roads, where it is supposed that tuna trade was important for the local economy.

According to the available information, most of the coins with tunas were mint during the III and II centuries b.C., because more ancient coins with tunas were found only in Cyzicus (VI b.C.), Charia Kinda (510 b.C.), Akragas (V b.C.), Solunto and Thurium (IV b.C.).

The places were coins with tunas were mint and the first period on which the coins with tunas were mint are the followings:

<table>
<tr><td>Turkey:
Byzantion (now Istanbul) – II b.C.
Cyzicus (now Aydincik) – VI b.C.</td><td rowspan="5">Spain:
Abdera (now Almeria) – II b.C.
Aipora (now San Lúcar de Barrameda) – II b.C.
Asido (now Medina Sidonia) – II b.C.
Bailo (near Playa de Bolonia) – I b.C.
Balsa (now Luz de Tavira) – II b.C.
Caura (now Cora del Rio) – II b.C.
Cumbaria (now Las Cabezas) – I b.C.
Gadir or Gadez (now Cadiz) – III b.C.
Ilipense (now Alcalá del Rio) – II b.C.
Ilse (close to Aznalcóllar) – II b.C.
Ituci (now Tejada la Nueva) – II b.C.
Lascuda (now Alcalá de los Gazules) – II b.C.
Malaka (now Malaga) – III b.C.
Sexs or Sexsi or Seks (now Almuñécer) – II b.C.
Turrirecina (uncertain, maybe Casas de Reina) - II b.C.</td></tr>
<tr><td>Greece:
Charia Kindia – VI b.C.</td></tr>
<tr><td>Italy:
Akragas (now Agrigento, Sicily) - V b.C.
Solunto (near Santa Flavia, Sicily) – IV b.C.
Thurium (near Sibari,, Calabria) – IV b.C.</td></tr>
<tr><td>Portugal:
Baesuris (now Castro Marim) – II b.C.
Mirtiles or Mértola (now Mortola) – II b.C.
Salacia Ketouibon (now Alcacer do Sal) – II b.C.</td></tr>
<tr><td>Morocco:
Lixus (near Larache) – II b.C.
Tingi (now Tanger) – II b.C.
Tamuda (now Tetuan) – III b.C.</td></tr>
</table>

From these data, it is very clear that the bluefin tuna reached an important economic importance revealed by coins at first in the eastern part of the Mediterranean basin (the Bosphorus, the Marmara Sea and the Aegean Sea), then in the central part (Sicily and Calabria). In this first period, many coins with tuna were mint particularly in Cyzicus, most using a particular league of metal called *electrum*[3], while others were mint in silver or bronze or in fourrée[4].

The western evidence of the commercial relevance of bluefin tuna is revealed only from the III century b.C. on. Most of the coins with tunas were mint during the Phoenician-Punic period and the Iberic one. Only very few ones were in silver, while the large majority was made in bronze.

Figures 6 to X show some of the several coins with tunas from various locations. Coins with tunas had various values and denominations: Hemihobol, Trihemiobol, Hobol, 1/48 Stater, 1/24 Stater, 1/12 Stater, Stater, El Hemihekte, El Hemihekte 1/48 Stater, 1/12 Stater, El Hekte, El Hekte 1/6 Stater, Double AE, Semis, As, Sextans, Quadrans or Quarter unit, half calcus, Hemidrachm, Drachm, Tetradrachm.

4. Discussion

This preliminary work provides some important elements which are useful for better understanding the distribution and relevance of fishing or commercial activities for bluefin tuna in classic historical times.

The information provided both by the geographic distribution of tuna salting factories and coins having the bluefin tuna represented on a side are telling us that the distribution of bluefin tuna was partly different in classic historical times if compared to the current distribution.

It is quite clear that important catches were obtained in several coastal areas by traps, confirming a major presence of tunas along many coast, including remote areas of the Azov Sea and the Black Sea, were bluefin is missing since about 35 years or even much more for the Azov Sea, even if precise data are missing. The distribution of many factories in the Atlantica areas close to the Strait of Gibraltar, in the Stait and in the Alboran Sea are a clear evidence of a massive migration of bluefin tuna at that time, while the distribution of factories along the coasts of Magreb and Sicily are another evidence of these coastal massive movements.

The tuna coins distribution shows a partly different image, with more focalised areas. The Marmara Sea and the Bosphorous were clearly important trading areas in very ancient times, at least from the VI century b.C. As a matter of fact, it seems that Cyzicus (now Aydincik) was the most important trading place for bluefin tuna over several centuries, while Byzantion (now Istanbul) become more important much later, but its relevance remained there up to the end of the Ottoman Empire, when Istanbul was the main market for the bluefin tuna fished in the Black Sea, in the Marmara Sea and in the Eastern Aegean Sea.

The large distribution of tuna coins in the western side of the Mediterranean Sea and in the adjacent part of the Atlantic Ocean confirms the very high economic importance of the bluefin tuna fishery and trade in these areas during the Phoenician and Roman times. It is also very clear that the fishery at those times was catching tunas coming from the Atlantic into the Mediterranean for spawning and bluefin tunas returning to the Atlantic foraging areas after spawning. Considering the various mints in the Iberian peninsula, it is also clear that salted bluefin tuna and garum were traded not only by ships travelling in the Mediterranean, but also by river vessels and charrets going inland for reaching towns far from the sea.

More difficult is the image coming from the distribution of tuna coins in the central Mediterranean areas, where bluefin tuna fishery was diffused in several areas, as testified by the salting factories. Tuna coins have been found so far only in a very few places in Sicily and Calabria, even if the distribution of mints during Phoenician and Roman time was considerable even in these areas. The reasons for this very limited distribution of tuna coins should be further investigated, because the presence of tuna salting factories testify an important commerce and then also a relevant economy, either in Phoenician or Roman and Greek times. It is inexplicable why tuna coins were not detected so far along the coast of Tunisia and Libya, while they are present in only two places in Sicily.

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[3] *Electrum* is a naturally occurring alloy of gold and silver, with trace amounts of copper and other metals. It was used for producing coins since 3,000 b.C. in ancient Egypt, and then by Greeks which used a man-made alloy with 45-55% of gold, instead of the percentage of 70-90% which were naturally present in Anatolia. Coins made with *electrum* were typical from Cyzinus. *Electrum* was called by Greeks “white gold”, while it is now currently called “green gold”.

[4] Fourrée is a coin made in non-precious metal and plated with precious metals such us gold or silver. This technique began in Asia Minor in the VII century b.C.

Certainly, during Roman times, when the production of *garum* was massive, the Emperos preferred to have their images and other symbols on the coins, while commercially important elements almost disappeared from all coins.

From a natural history point of view, the most relevant for ICCAT and SCRS purposes, the main points are the followings:

- The large presence of bluefin tuna in the Black Sea, up to the Azov Sea, during classic historical times, while bluefin tuna disappeared from the Black Sea in the '80s;
- The massive presence of bluefin tuna in all coastal areas of the Mediterranean Sea (with a much more important distribution along the traditional migratory course crossing the southern part of the basin) and in the Atlantic areas close to the Strait of Gibraltar; from the second part of the XX century, bluefin tuna is mostly concentrated in offshore waters in the Mediterranean Sea, as a result of the environmental changes occurred in most of the coastal areas.

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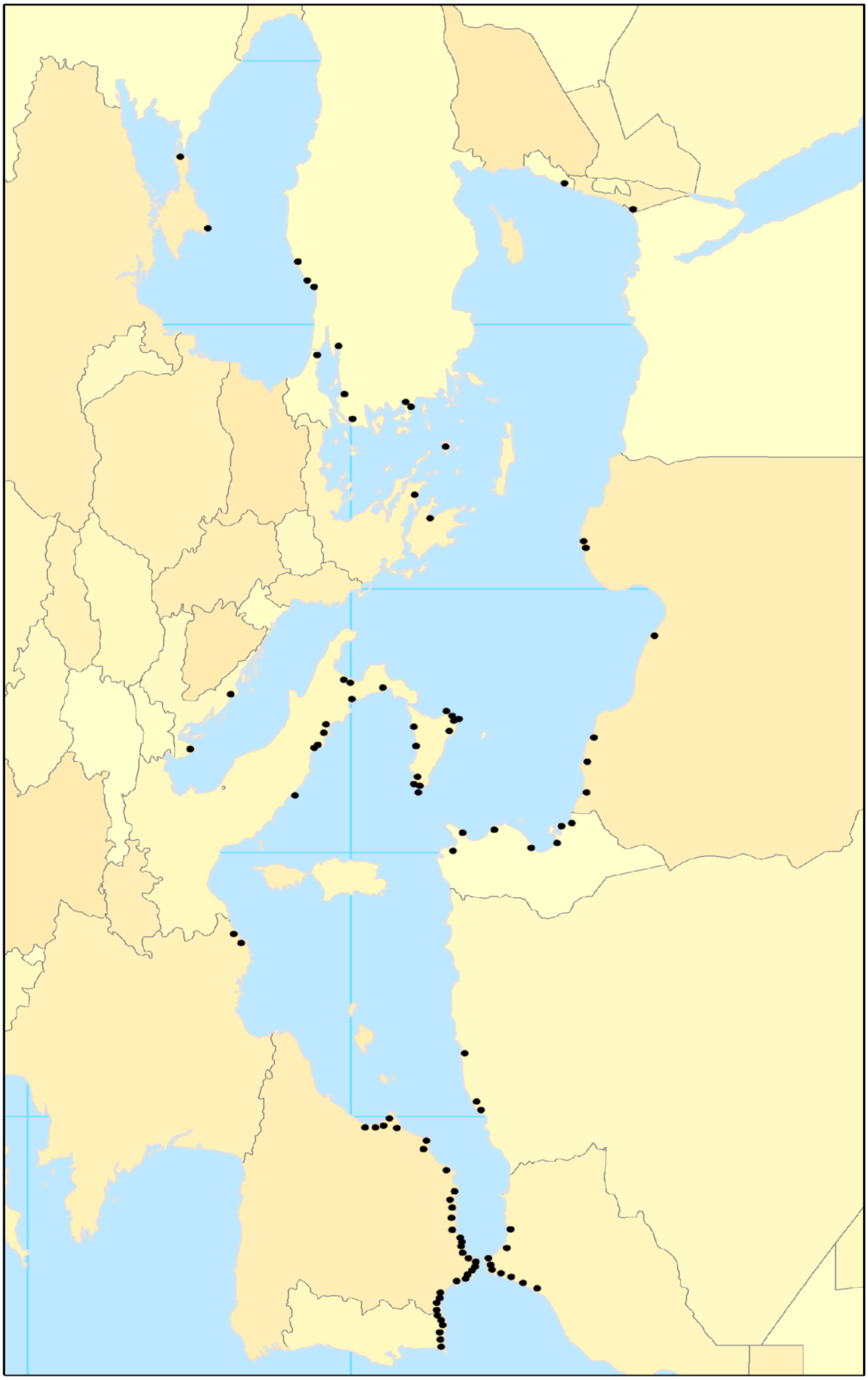

Figure 1. Distribution of the main fish salting factories in classic historical times (from V b.C. to V a.C.) in the Mediterranean Sea and in the adjacent seas.

Figure 2. Fish salting factory in Baelo Claudia (South Spain).

Figure 3. Fish salting factory in Lixus (Atlantic coast of Morocco).

Figure 4. Fish salting factory in Tipaza (Algeria).

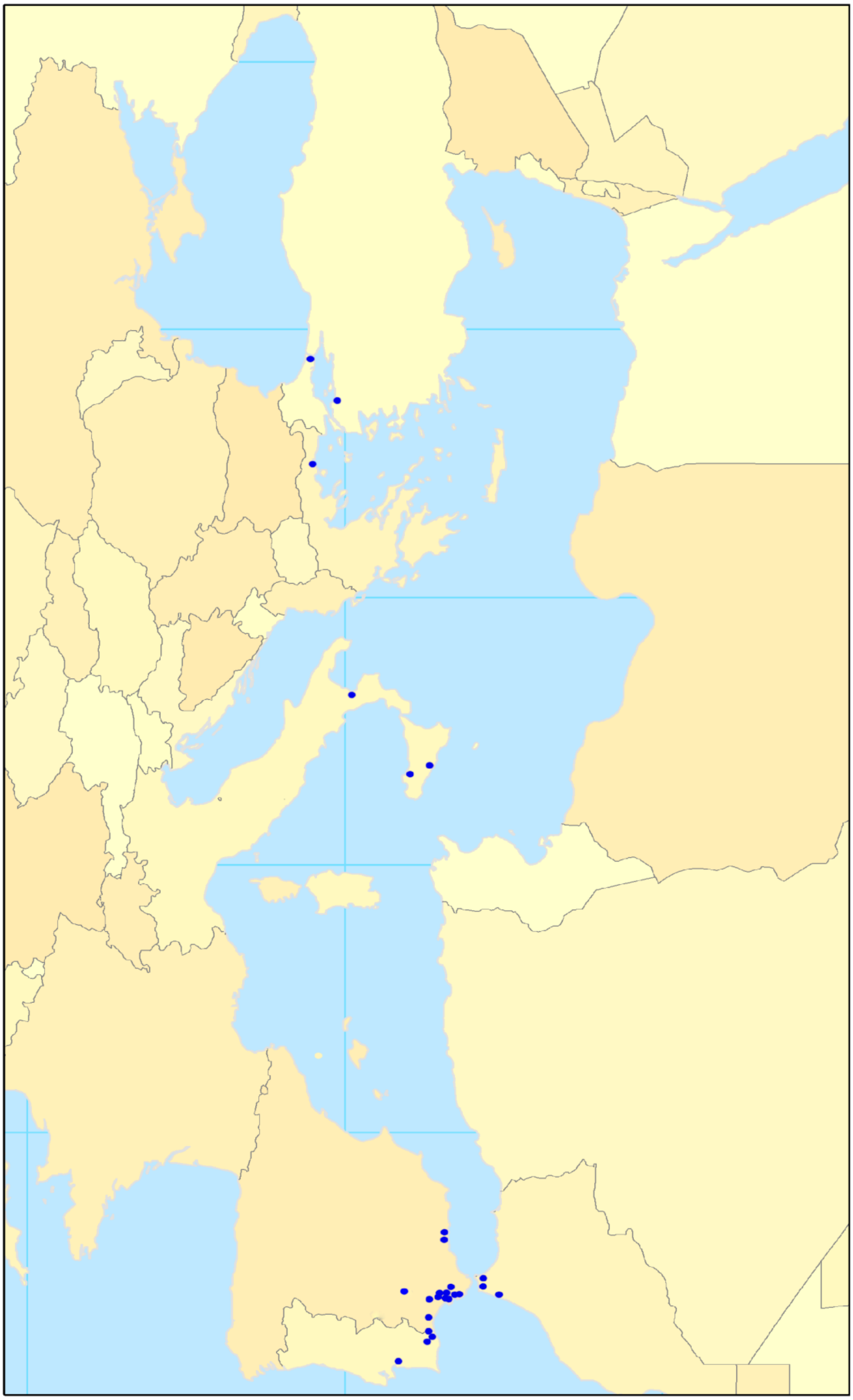

Figure 5. Distribution of ancient towns where coins with tuna were mint in classic historical times (from V b.C. to V a.C.) in the Mediterranean Sea and in the adjacent seas.

a b

Figure 6a (left). Hemiobol, Greek coin in silver from Cyzicus, c. 450 b.C. (0.36 g); obverse: forepart of boar running left, tunny fish upwards behind; reverse: head of roaring lion left, star of four rays above. **Figure 6b (right)**: Trihemiobol, Greek coin in silver from Cyzicus, c. 480 b.C. (0.82 g); forepart of boar running left, tunny fish upwards behind; reverse: head of roaring lion left.

a b

Figure 7a (left). Obol, Greek coin in silver from Cyzicus, c. 480 b.C. (0.80 g); obverse: forepart of boar running left, tunny fish upwards behind; reverse: head of roaring lion left, with incuse square. **Figure 7b (right)**: El 1/48 Stater, Greek coin in silver from Cyzicus, c. 600 b.C. (0.39 g); obverse: head of tuna right; reverse: incuse square with swastika.

a b

Figure 8a (left). El 1/24 Stater, Greek coin in electrum from Cyzicus, V b.C. (0.69 g); obverse: Zeus AËtophoros kneeling right on tunny right; reverse: incuse square with swastica. **Figure 8b (right)**: El 1/12 Stater, Greek coin in electrum from Cyzicus, c. 500 b.C. (1.34 g); obverse: ram’s head left, tuna above; reverse: quadripartite incuse square with swastica.

a b

Figure 9a (left). El Stater, Greek coin in electrum from Cyzicus, c.500 b.C. (16.1 g); obverse: Head of Apollo, wearing laurel wreath, facing slightly right; below, tuna right; reverse: quadripartite incuse square. **Figure 9b (right)**: El Stater, Greek coin in electrum from Cyzicus, c. 500 b.C. (16.23 g); obverse: Panther standing left on tuna, raising right forepaw; reverse: quadripartite incuse square.


a b

Figure 10a (left). El Hemihekte, Greek coin in electrum from Cyzicus, c.500 b.C. (1.3 g); obverse: Triton left holding wreath in left hand, on tuna left; reverse: quadripartite incuse square. **Figure 10b (right)**: El Hemihekte, Greek coin in electrum from Cyzicus, c. 600 b.C. (1.33 g); obverse: Panther standing left on tuna, raising right forepaw; reverse: quadripartite incuse square.


a b

Figure 11a (left). El Hemihekte 1/12 Stater, Greek coin in electrum from Cyzicus, c.550 b.C. (1.33 g); obverse: Triton(?) left, holding tuna; head of tuna to left; reverse: quadripartite incuse square. **Figure 11b (right)**: El Hekte 1/6 Stater, Greek coin in electrum from Cyzicus, c. 600 b.C. (2.71 g); obverse: Eagle standing right on tuna left; to upper left, tuna right; reverse: quadripartite incuse punch.


a b

Figure 12a (left). El Hekte 1/6 Stater, Greek coin in fourrée from Cyzicus, c.500 b.C. (2.01 g); obverse: Sphinx standing left; below, tuna left; reverse: quadripartite incuse punch. **Figure 12b (right)**: El Hekte, Greek coin in electrum from Cyzicus, c. 500 b.C. (2.67 g); obverse: Facing head of gorgoneion with protruding tongue, set on tuna left; reverse: quadripartite incuse square.


a b

Figure 13a (left). El Hekte, Greek coin in fourrée from Cyzicus, c.500 b.C. (2.01 g); obverse: Sphinx standing left; below, tuna left; reverse: quadripartite incuse square. **Figure 13b (right)**: El Hekte, Greek coin in electrum from Cyzicus, V b.C. (16.7 g); obverse: Head of Attis right, wearing Phrygian headdress; below, tuna right; reverse: quadripartite incuse square.

a b

Figure 14a (left). Double AE, neo-Punic Phoenician coin in bronze from Sexis, II b.C.; obverse: Melkart head right, club on left shoulder; reverse: two tunas right, SKS inscrption. **Figure 14b (right)**: Semis, neo-Punic Phoenician coin in bronze from Sexis, c. 200 b.C. (4.4 g); obverse: Helmet male head right; reverse: Tuna-fish right, Phoenician letter 'aleph' above.

a b

Figure 15a (left). Semis, Phoenician Punic coin in bronze from Gadir, II b.C.; obverse: Head of Melkart-Herakles left, wearing lion's skin headdress; club on left shoulder; reverse: Tuna left, Phoenician script MP'L above and 'GDR below. **Figure 15b (right)**: Semis, Iberian coin in bronze from Baesuri, II b.C. (2.2 g); obverse: inscription BAE; reverse: Tuna-fish left.

a b

Figure 16a (left). Semis, Phoenician Punic coin in bronze from Sexsi, c. 200 b.C. (4.4 g); obverse: helmet male head right; reverse: Tuna-fish right, Phoenician letter "aleph" above, neo-Punic inscription SKS below. **Figure 16b (right)**: As, Iberian coin in bronze from Ilipense, c. 200 b.C. (35 g); obverse: grain ear; reverse: Tuna-fish swimming right, crescent above between two stars, legend "ILIPENSE" below.

a b

Figure 17a (left). As, Phoenician Punic coin in bronze from Abdera, II b.C.; obverse: Tetrastyle 5temple; reverse: Punic inscription BDRT, two tuna fish left. **Figure 17b (right)**: As, Phoenician Punic coin in bronze from Salacia - Ketouibon, c. 150 b.C. (13.53 g); obverse: inscriptrion CAVONIE SISCRA, laureate bearded head facing to left, dotted border; reverse: two tunas swimming right.


a

b

Figure 18a (left). Sextants (?), Phoenician Punic coin in bronze from Gadir, I b.C.; obverse: Head of Melkart-Herakles left, wearing lion's skin; reverse: tuna left, Phoenician letter “aleph” below. **Figure 18b (right)**: Quadrans – Quarter unit, Phoenician Punic coin in bronze from Gadir, 237 b.C.; obverse: Helios head facing; reverse: Phoenician script MP'L above and 'GDR below, Phoenician letter 'aleph' between two tuna-fish right.

a

b

Figure 19a (left). Quadrans – Quarter unit, Phoenician Punic coin in bronze from Ituci, I b.C.; obverse: grain hear; reverse: legend ITUCI, tuna right, crescent above. **Figure 19b (right)**: unknown Greek coin unit from Thurium, IV b.C.; obverse: helmeted bust of Athena right; reverse: Bull right, head reverted; tuna fish right in exergue.


a

b

Figure 20a (left). Hemidrachm, Phoenician Punic coin in silver from Gadir, 237 b.C. (2.36 g); obverse: Head of Melkart-Herakles left, wearing lion's skin headdress; club on left shoulder; reverse: tuna-fish left Phoenician script MP'L above and 'GDR below. **Figure 20b (right)**: Drachm, Phoenician Punic coin in silver from Gadir, III b.C. (3.3 g); obverse: Head of Melkart-Herakles left, wearing lion's skin headdress; club on left shoulder; reverse: tuna-fish left Phoenician script MP'L above and 'GDR below.


a

b

Figure 21a (left). Tetradrachm, Phoenician Punic coin in silver from Cyzicus, 350 b.C. (15.21 g); obverse: ΣΩΤΕΙΡΑ, Head of Kore Soteira left, hair in sakkos; reverse: legend KI-ZI, Head of lion left, tuna fish left below; wreath behind. **Figure 21b (right)**: Tetradrachm, Phoenician Punic coin in silver from Cyzicus, 413 b.C. (14.67 g); obverse: ΦΑΡ−Ν−[Α]−ΒΑ, head of Pharnabazos right, weaing satrapal cap tied below his chin, and diadem; reverse: Ornate ship’s prow left, decorated with a griffin and prophylactic eye; before and aft, two dolphins downward; below, tuna left.

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REPORT OF JAPAN'S SCIENTIFIC OBSERVER PROGRAM FOR TUNA LONGLINE FISHERY IN THE ATLANTIC OCEAN IN THE FISHING YEARS 2011 AND 2012

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SUMMARY

Japan's scientific observer program for longline fishery in the Atlantic Ocean has been continuously carried out in 2012 fishing years (FY). This document mainly provides the summary of collected data by observers in 2012 FY, and the summary in 2011 FY were also updated. In 2012 FY, 12 observer trips were conducted on Japanese tuna longline vessels in the entire Atlantic Ocean, while observers had 18 trips in 2011 FY. Total number of fishing operations with observers was 582 (1,083,195 hooks) in 2012 FY, whereas 620 (1,711,834 hooks) were monitored in 2011 FY. In each FY, more than 19,000 individuals were recorded by scientific observers. Details of trips and catch records were shown, and the coverage level based on the number of operating days was provided. The nominal CPUE (number of fish caught per 1000 hooks) by fishing area for major species were also calculated.

RESUME

Le programme japonais d'observateurs scientifiques pour la pêcherie palangrière de l'océan Atlantique a été réalisé sans interruption tout au long de l'année de pêche 2012. Le présent document fournit principalement un résumé des données collectées par les observateurs pendant l'année de pêche 2012 ; le résumé de l'année de pêche 2011 a également été mis à jour. Au cours de l'année de pêche 2012, 12 sorties d'observateurs ont été réalisées sur des palangriers thoniers japonais dans l'ensemble de l'océan Atlantique, tandis que les observateurs ont effectué 18 sorties au cours de l'année de pêche 2011. Le nombre total d'opérations de pêche avec observateurs était de 582 (1.083.195 hameçons) pendant l'année de pêche 2012, alors que 620 opérations de pêche (1.711.834 hameçons) avaient fait l'objet d'un suivi pendant l'année de pêche 2011. Au cours de chaque année de pêche, plus de 19.000 spécimens ont été enregistrés par des observateurs scientifiques. Des informations détaillées sur les sorties et les registres de capture ont été présentées et le niveau de couverture basé sur le nombre de jours d'opérations a été fourni. La CPUE nominale (nombre de poissons capturés pour 1.000 hameçons) par zone de pêche pour les principales espèces a également été calculée.

RESUMEN

El programa de observadores científicos de Japón para la pesquería de palangre en el océano Atlántico se desarrolló de forma continua durante el año pesquero (FY) 2012. Este documento proporciona sobre todo un resumen de los datos recopilados por los observadores en el año pesquero 2012; también se ha actualizado el resumen del año pesquero 2011. En el año pesquero 2012, se realizaron 12 mareas con observadores en los buques de palangre de atún japoneses en todo el océano Atlántico, mientras que en el año pesquero 2011 hubo 18 mareas con observadores. El número total de operaciones de pesca con observadores ascendió a 582 (1.083.195 anzuelos) en el año pesquero de 2012, mientras que en el año pesquero 2011 se observaron 620 operaciones de pesca (1.711.834 anzuelos). En cada año pesquero, los observadores científicos registraron más de 19.000 ejemplares. Se presenta información detallada sobre las mareas y registros de captura, así como el nivel de cobertura basado en el número de días operativos. También se ha calculado la CPUE nominal (número de ejemplares capturados por 1.000 anzuelos) por zona de pesca para las principales especies.

KEYWORDS

Longline, Japan, Observer CPUE, Scientific observer, Tuna fisheries

Introduction

Japan has continuously conducted its national scientific observer programs on Japanese tuna longline vessels in the Atlantic Ocean since the mid 1990s, and this program have played a major role in response to the recommendations made by ICCAT since 1996. Various data have been collected through the observer programs, and that includes vessel attributes, gear configuration, species identification, biological sampling and various measurements on all observed catches. These collected data have been summarized until 2012, and been reported to SCRS meetings (Matsumoto and Miyabe, 1997, 1998, 1999, 2000, 2001; Matsumoto *et al.*, 2002, 2003, 2004, 2005; Matsumoto, 2006; Semba *et al*. 2007, 2008; Japan, 2011; Japan, 2012).

This document overviews Japan's scientific observer programs conducted in the entire Atlantic Ocean, and provides the summary of collected data mainly from September 2012 to December 2012 which were in 2012 fishing years (FY, thereafter, fishing year starts from August to next July). The summary which were already reported in 2012 (Japan, 2012) was revised, because some additional observer data in 2011 FY were newly compiled. In accordance with the 2010 Recommendation [Rec. 10-10] on minimum standards for fishing vessel scientific observer programs, catch rates, the coverage level, and its details were also contained in this document.

Outline of the observer program

In principal, all observers attended a training class held by National Research Institute of Far Seas Fisheries before the departure for the cruises. The observer training program included keys for species identification, data recording protocols for information on fishing operation and catches, and protocols for taking various measurements for catches. During fishing operations the observers recorded various information and collected as many data and biological samples as possible. When there were substantial numbers of catch, priority on the observers' records was given to tunas and billfishes but the number of catch was counted for all species.

Contents of observers' records

i) General information of fishing operations

Various information of observed fishing activities were recorded. The name and attributes of the observed fishing vessel, and oceanographic and weather condition were recorded. At each fishing operation, date, location, the number of radio-buoys, hooks, gear configuration and bait used were also recorded. In addition, the number of sea birds flown during line setting were observed once in several days.

ii) Identification of species and related information

All catches taken on the deck were identified its species and recorded while the observers were on the deck for their research. The catches which were not hauled up on the deck were also recorded. For double check of species identification, digital photos of observed catches were sometimes taken.

For each catch, retrieving time, the branch number on which the catch was hooked, and the life status of the catch (alive or dead; "alive" was further separated into "no details", "vigorous", "sluggish" or "injured") were recorded as much as possible. The life status was immediately identified on the deck or at the deck side for releasing.

iii) Measurement of catch

Lengths were measured for all intact catches by 1cm interval (round up) and the following measurements were applied for different fish groups; fork length for tunas, post-orbit fork length (POFL) for billfishes, precaudal length for sharks, disk length for rays, total or fork length for other teleosts. A caliper was used for the measurement. Clasper inner length (between the anterior margin of the cloaca and the posterior clasper tip) was measured and recorded for male sharks by 0.1 cm interval.

Whole body weight (to the nearest 0.1kg in principal), processed weight (to the nearest 1 kg) and gonad weight (for tunas and billfishes; to the nearest 0.1kg) were measured as much as possible.

iv) Sex determination and biological sampling

Sex determination was conducted through the observation of genital gland for teleosts and with or without of clasper for sharks and rays. Biological sampling mainly for tunas and sharks was sometimes conducted for muscle, stomach contents, otolith and hard parts.

Results

i) Trip and observer coverage

Japan's observer program has been continuously carried out through 2012 FYs. Details of observer trips, which were defined equal to the number of vessels with observers, by fishing year were shown in **Table 1**. In 2011 FY, five trips in the southern Atlantic Ocean and two trips in the tropical Atlantic Ocean were newly complied and added to the original results in the previous report (Japan, 2012). In 2011 and 2012 FYs, observers had 18 and 12 trips on Japanese tuna longline vessels in the entire Atlantic Ocean (the ICCAT convention area), respectively. In the north Atlantic, 12 and 12 trips were observed in 2011 and 2012 FYs, respectively. The trips in the south Atlantic monitored a part of fishing activities for southern bluefin tuna, and 5 trips were carried out in 2011 FY. The data in 2012 FY are not available at present.

The coverage level achieved within Japanese longline vessels was estimated based on the number of operating days. The ratio was calculated by dividing the number of operating days with observers by the total number of operating days which were from the available latest logbook data in August, 2013. Japan's observer programs covered 3.9% fishing activities in the entire Atlantic Ocean in 2012 calendar year (638 days with observers/ 16175 days), while it was 3.2% in 2011 calendar year (656 days with observers/ 20226 days). The coverage level for the Japanese longline vessels targeting Atlantic bluefin tuna achieved 34.4% (408 days with observers/1187 days) and 35.5% (253 days with observers/713 days) in 2011 and 2012 FYs, respectively.

ii) Observed operations

Total number of observed fishing operations was 620 and 582 during 904 and 1784 days in which observers were on board in 2011 and 2012 FYs, respectively. Total hooks in all operations with observers were 1,083,195 and 1,711,834 hooks in 2011 and 2012 FYs, respectively.

The distribution of hooks in all operations with observer was shown in Figure 1. The area of operation was divided into six areas; off Ireland, central north, off Grand Bank, off Florida, tropical area, and off Cape Town. Main observed areas were off Ireland and tropical area, and the numbers of trips were 11 and 10 in 2011 and 2012 FYs, respectively. Since 2010 FY, off Florida were not monitored. The area off Cape Town were observed by 5-6 vessels every year.

iii) Catch records

The lists of species recorded by scientific observers in 2011 and 2012 FYs were shown in **Table 2**. The lists were compiled mainly for tunas, and billfishes. The number of observed individuals was 25,233 in 2012 FY, while 19,014 were recorded in 2011 FY. In 2011 FY, about 30% of individuals were observed in the area off Ireland, central north, or off Grand Bank, whereas about 55% of individuals were recorded in the tropical area in 2011 FY. This is mainly due to the shorter fishing season of Atlantic bluefin with a higher catch rate since 2011 FY (**Table 4**), thus more operations in the tropical areas were monitored by observers compared to other fishing years.

Figure 2 shows that species composition in each area by fishing year for 6 main species which constituted the majority of total observed catch: albacore, yellowfin, bigeye, Atlantic bluefin, southern bluefin, and blue shark. In the area off Ireland, Atlantic bluefin and blue shark were the dominant species, which accounted for 42% and 58% of total catch of main 6 species in terms of number of fish in 2012 FY, and 91% and 9% in 2011 FY. The occurrence of other species was few (less than 1%). In the central north, blue shark was the most dominant species and accounted for 54-84%.

In the area off Grand Bank, blue shark was the dominant species in both 2011 (35%) and 2012 FYs (66%). Atlantic bluefin were consistently observed and accounted for 20% of the total catch of main 6 species. Bigeye was also dominant species in 2011 FY (43%). In the area off Florida, there was no trip with observers since 2010 FY.

In the tropical area, bigeye was also the most dominant species in 2011 (30%) and 2012 FYs (47%), while albacore, yellowfin, and blue shark were similarly observed, which accounted for 13-27%. In the area off Cape Town, southern bluefin tuna was the most dominant species (34%), while albacore (31%) and bigeye (19%) were also observed. The data has been collecting in 2012 FY, and the information would be updated in 2014.

The number of fish measured, recorded or sampled by species through 2011 to 2012 FYs was indicated for each item in **Table 3**. Lengths of tunas and billfishes were measured for 89% and 98% of total observed catch in number in 2011 and 2012 FYs, respectively. More than 86% of tunas and billfishes were measured its processed weight. Biological sampling was made mainly for bluefin, southern bluefin and sharks.

iv) Catch ratio of main species

CPUE (catch number per 1000 hooks) of 6 main species by area was calculated for the period between 2011 and 2012 FYs (**Table 4**). Total hooks in all operations with observers by area by fishing year were used as effort for the calculation. The CPUE of albacore was the highest in the tropical area in 2012 FY, whereas the high CPUE was observed both in the off Cape Town and tropical area in 2011 FY. For tropical tunas, the CPUEs of bigeye and yellowfin were the highest in the tropical area in 2011 and 2012 FYs, while a high CPUE was observed for bigeye in the area off Grand Bank in 2011 FY.

For Atlantic bluefin tuna, significant CPUE values (CPUE>5 fish per 1000 hooks) were observed in the areas off Ireland and central north both in 2011 and 2012 FYs. In the area off Grand Bank. Southern bluefin tuna was caught in the area off Cape Town, and the CPUE in 2011 FY was 1.22. The CPUE of blue shark was significant mainly in the central north in both FYs, especially in 2012FY with 28.56.

Acknowledgement

We greatly appreciate all scientific observers for their efforts in order to collect valuable data and samples on the Japanese longline vessels. We would also like to express special thanks to all crews of the longline vessels for their understanding and cooperation to the observer program.

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Table 1-a). Updated information on the trip of the scientific observer for Japanese tuna longline in the Atlantic Ocean during 2011FY. The trips: RT1101 to AT1114 were newly compiled and added, and other trips, which was already provided in 2012, were updated.

Trip ID	Main fishing ground	Range of latitude	Range of longitude	Start date of operation	End date of operation	Number of operation observed	Number of hooks observed
AT1101	off Grand Bank	28.2-47.6N	15.4-53.6W	2011/9/8	2011/11/30	70	192848
AT1102	off Ireland	45.9-60N	24.3-44.7W	2011/9/25	2011/10/15	15	43744
AT1103	off Ireland	8.9-60N	22-79.9W	2011/9/28	2011/10/24	20	59168
AT1104	off Ireland, tropical area	10-60N	5.8-35W	2011/10/1	2011/12/9	56	174020
AT1105	off Ireland, tropical area	5.6-59.1N	10-35.1W	2011/10/8	2011/12/12	50	152190
AT1106	off Ireland, tropical area	9.4-59.4N	15.4-31.1W	2011/10/9	2011/12/7	39	115430
AT1107	off Ireland, tropical area	6.3-59.7N	14.8-35.6W	2011/10/13	2011/12/6	38	108916
AT1108	off Ireland, tropical area	10.6-59.9N	18.2-76W	2011/10/20	2011/12/18	44	133450
AT1109	off Ireland, central north, tropical area	10-56.9N	17.2-32.1W	2011/10/20	2011/12/10	37	101027
AT1110	off Grand Bank	10.4-42.7N	47.7-78.7W	2011/10/22	2011/12/25	55	141294
AT1111	off Ireland, tropical area	10.2-55.5N	15.3-33.9W	2011/10/30	2011/12/10	27	85914
RT1101	off Cape Town	42.6-44.1S	7.5-15.9E	2012/3/14	2012/5/2	25	75350
RT1102	off Cape Town	35-44.1S	6.3-16.1E	2012/4/16	2012/5/28	39	122183
RT1103	off Cape Town	36.4-44.6S	7.3-15.5E	2012/4/19	2012/6/29	27	80250
RT1104	off Cape Town	17.1-43.9S	5.9-9.4E	2012/5/5	2012/7/7	47	151864
RT1105	off Cape Town	36.8-41.8S	19.9-27.8E	2012/5/16	2012/7/8	2	5578
AT1113	tropical area	14.2-16.2N	25.3-27.4W	2012/7/12	2012/7/31	16	43571
AT1114	tropical area	14.1-17.3S	92.4-94.8W	2012/7/15	2012/7/31	13	33798

Table 1-b). Information on the trip of the scientific observer for Japanese tuna longline in the Atlantic Ocean during 2012 FY.

Trip ID	Main fishing ground	Range of latitude	Range of longitude	Start date of operation	End date of operation	Number of operation observed	Number of hooks observed
AT1201	off Ireland, tropical area	60.1N-16.6S	25.6-93.2W	2012/8/1	2012/11/1	45	117667
AT1202	off Ireland, tropical area	7.8-59.9N	19.5E-26.8W	2012/8/1	2012/11/8	64	172910
AT1203	off Grand Bank	40.9-46.6N	46.5-52.6W	2012/8/11	2012/11/5	69	195375
AT1204	off Grand Bank	41.1-46.4N	46.1-52.7W	2012/8/24	2012/11/7	64	187386
AT1205	off Ireland	58.3-59.7N	24.6-28.5W	2012/9/21	2012/10/30	20	57576
AT1206	off Ireland	58.1-59.7N	21.1E-23.7W	2012/9/22	2012/11/3	19	50512
AT1207	off Ireland, central north	54.2-58.4N	24-32.4W	2012/9/30	2012/11/21	23	65520
AT1208	off Ireland, central north, tropical area	10.3-55.2N	26.5-44.9W	2012/10/14	2013/1/28	64	203370
AT1209	off Ireland	56.4-58.9N	22.3-25.2W	2012/10/21	2012/11/18	12	36000
AT1210	tropical area	5.1-16.3N	31.2-36.3W	2012/10/31	2012/12/28	45	144180
AT1211	tropical area	12.2-22.9N	17.4-33.9W	2012/11/4	2013/1/23	66	198360
AT1212	tropical area	4.8N-15.3N	17.9E-33.3W	2013/1/2	2013/4/19	91	282978

Table 2-a). Updated list of species recorded by the Japanese tuna longline observer in the Atlantic Ocean during 2011 FY.

Species	off Ireland	central north	off Grand Bank	off Florida	tropical area	off Cape Town	Total
Albacore	0	5	33	-	1695	884	2617
Bigeye tuna	0	0	914	-	2034	544	3492
Bluefin tuna	2453	148	441	-	-	0	3042
Southern bluefin tuna	-	-	-	-	-	971	971
Yellowfin tuna	0	0	13	-	1536	115	1664
Other tunas	0	0	0	-	77	335	412
Blue marlin	0	0	0	-	131	0	131
Longbill spearfish	0	0	2	-	35	0	37
Sailfish	0	0	0	-	41	0	41
Swordfish	0	1	172	-	195	19	387
White marlin	0	0	1	-	21	2	24
Other teleosts	54	1	26	-	1683	319	2083
Blue shark	238	179	749	-	1618	376	3160
Other sharks	17	1	114	-	395	373	900
Sea birds	0	0	0	-	1	12	13
Sea turtles	0	0	1	-	33	0	34
Dolphins	0	0	0	-	0	1	1
Unidentified	0	0	3	-	2	0	5
Total	2762	335	2469	-	9497	3951	19014

Table 2-b). List of species recorded by the Japanese tuna longline observer in the Atlantic Ocean during 2012 FY.

Species	off Ireland	central north	off Grand Bank	off Florida	tropical area	off Cape Town	Total
Albacore	0	4	9	-	2968	-	2981
Bigeye tuna	0	0	169	-	5113	-	5282
Bluefin tuna	1811	200	221	-	0	-	2232
Southern bluefin tuna	-	-	-	-	-	-	0
Yellowfin tuna	0	0	5	-	1397	-	1402
Other tunas	0	0	0	-	149	-	149
Blue marlin	0	0	1	-	66	-	67
Longbill spearfish	0	0	2	-	46	-	48
Sailfish	0	0	0	-	49	-	49
Swordfish	0	0	197	-	231	-	428
White marlin	0	0	3	-	47	-	50
Other teleosts	74	6	49	-	3829	-	3958
Blue shark	2491	1055	769	-	1409	-	5724
Other sharks	6	3	147	-	636	-	792
Sea birds	0	0	6	-	13	-	19
Sea turtles	0	0	2	-	46	-	48
Pinnipedia	1	0	0	-	0	-	1
Dolphins	0	0	1	-	2	-	3
Total	4383	1268	1581	-	16001	-	23233

Table 3-a). Updated the number of individuals measured or sampled by species in 2011 FY.

Species	Number of observed/measured indivisuals						Biological sampling			
	Length	Processed weight	Whole weight	Sex	Gonad weight	Maturity	Otolith	Muscle	Stomach	Gonad
Albacore	2561	1974	0	464	408	405	0	17	0	21
Bigeye tuna	3208	3368	0	3298	17	217	106	270	97	1
Bluefin tuna	2827	2812	0	2631	0	190	130	376	82	0
Southern bluefin tuna	1433	1434	0	1428	0	0	0	0	0	0
Yellowfin tuna	1643	1630	0	1590	4	46	65	71	1	0
Other tunas	237	403	0	351	0	0	0	0	0	0
Blue marlin	123	123	0	118	0	3	0	1	1	0
Longbill spearfish	37	36	0	33	0	1	0	0	0	0
Sailfish	40	38	0	30	0	0	0	0	0	0
Swordfish	358	357	0	329	3	20	0	22	20	1
White marlin	66	63	0	54	0	5	0	2	0	0
Other teleosts	1131	1129	0	687	118	113	0	0	0	0
Blue shark	2707	2646	0	2797	204	729	1	317	6	3
Other sharks	590	348	0	401	213	234	0	61	23	89
Sea birds	1	7	0	1	0	0	0	0	0	0
Sea turtles	2	0	0	2	0	0	0	0	0	0
Dolphins	0	0	0	0	0	0	0	0	0	0
Unidentified	0	0	0	0	0	0	0	0	0	0
Total	16964	16368	0	14214	967	1963	302	1137	230	115

Table 3-b). The number of individuals measured or sampled by species in 2012 FY.

Species	Number of observed/measured indivisuals						Biological sampling			
	Length	Processed weight	Whole weight	Sex	Gonad weight	Maturity	Otolith	Muscle	Stomach	Gonad
Albacore	2728	2732	0	391	0	1	0	1	0	0
Bigeye tuna	5011	4947	0	4554	0	832	87	204	0	0
Bluefin tuna	2175	2111	0	2107	6	395	300	395	1	0
Southern bluefin tuna	-	-	-	-	-	-	-	-	-	-
Yellowfin tuna	1302	1322	0	1039	0	242	40	99	0	0
Other tunas	110	81	0	17	0	0	0	0	0	0
Blue marlin	60	59	0	49	0	4	0	17	0	0
Longbill spearfish	46	47	0	43	0	0	0	5	0	0
Sailfish	49	49	0	32	0	0	0	10	0	0
Swordfish	378	352	0	319	3	15	0	101	0	0
White marlin	48	47	0	39	0	9	0	8	0	0
Other teleosts	1505	1378	0	633	0	6	0	3	0	0
Blue shark	3170	3231	0	3342	1	462	2	112	0	0
Other sharks	444	372	0	422	0	26	0	85	0	0
Sea birds	12	12	0	6	0	0	0	0	0	0
Sea turtles	2	2	0	2	0	0	0	0	0	0
Pinnipedia	0	0	0	0	0	0	0	0	0	0
Dolphins	0	0	0	0	0	0	0	0	0	0
Total	17040	16742	0	12995	10	1992	429	1040	1	0

Table 4-a). Updated catch ratio (/1000hooks) of main species in 2011 FY.

	Albacore	Yellowfin tuna	Bigeye tuna	Bluefin tuna	Southern bluefin tuna	Blue shark
off Ireland	0.00	0.00	0.00	7.42	-	0.72
central north	0.24	0.00	0.00	7.12	-	8.61
off Grand Bank	0.10	0.04	2.74	1.32	-	2.24
off Florida	-	-	-	-	-	-
tropical area	2.42	2.20	2.91	-	-	2.31
off Cape Town	2.06	0.27	1.27	-	2.26	0.88

Table 4-b). Catch ratio (/1000hooks) of main species in 2012 FY.

	Albacore	Yellowfin tuna	Bigeye tuna	Bluefin tuna	Southern bluefin tuna	Blue shark
off Ireland	0.00	0.00	0.00	6.26	-	8.61
central north	0.11	0.00	0.00	5.41	-	28.56
off Grand Bank	0.02	0.01	0.44	0.58	-	2.01
off Florida	-	-	-	-	-	-
tropical area	4.34	2.04	7.48	-	-	2.06
off Cape Town	-	-	-	-	-	-

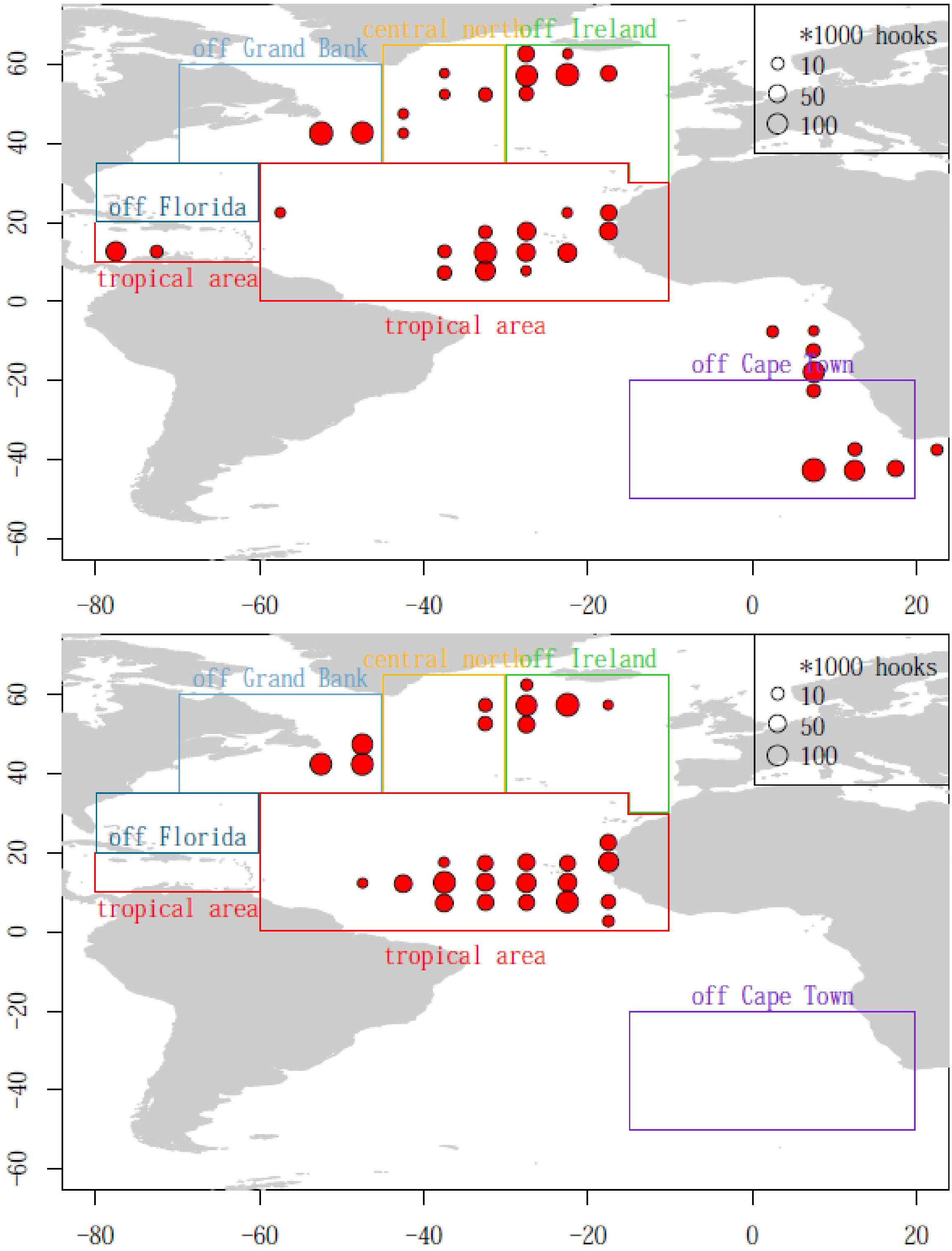

Figure 1. Distribution of total hooks with observers in the Atlantic Ocean by fishing year, and definition of 6 areas: off Ireland, central north, off Grand Bank, off Florida, tropical area, off Cape Town. Upper panel shows 2011 FY, and lower panel shows 2012 FY.

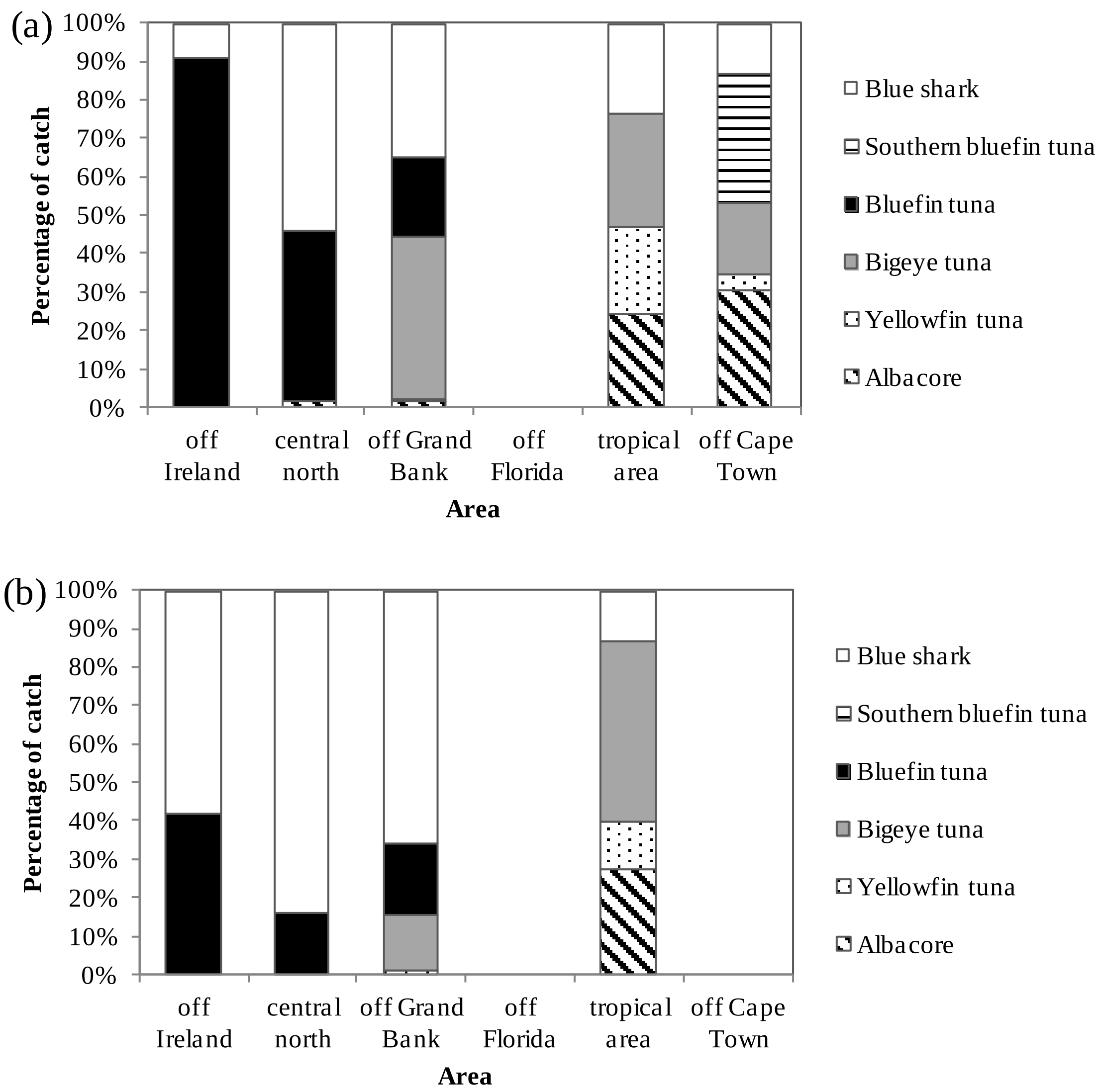

Figure 2. Catch composition of main species in the 6 areas by fishing year ((a) updated 2011 and (b) 2012FYs).

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ANALYSIS OF SMALL-SIZE FLEET FISHERY BASED IN CABO FRIO CITY, RIO DE JANEIRO-BRAZIL (2003-2012)

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SUMMARY

Multispecific small-fleet in Southwestern Atlantic (Cabo Frio City, Rio de Janeiro-RJ State, Brazil) is comprised by small boats that catch 15% of RJ total yield. Stimulated by the productivity caused by the upwelling water, landing facilities and Cabo Frio City industries, since 2000, this fleet has been growing in number of boat reaching the number of 350 vessels in 2010. It represents an important fishing area off Rio de Janeiro State (22^o S to 24^o S and 40^o W to 44^o W), and the total production from 2003 to 2012 was 2,752 tons. The target species was mainly the dolphinfish using surface longline. The sailfish was also caught by surface longline and the yellowfin tuna was captured basically by hand line, while the little tuna was mostly caught by small purse seine. The analysis also includes length frequency of size distributioning of the dolphinfish, sailfish, yellowfin and little tuna from 2003 to 2012.

RÉSUMÉ

La flottille plurispécifique de petite taille opérant dans l'Atlantique Sud-Ouest (ville de Cabo Frio, état de Rio de Janeiro, Brésil) se compose de petits bateaux qui capturent 15% de la production totale de Rio de Janeiro. Stimulée par la productivité causée par la remontée de l'eau, les installations de débarquement et les industries dans la ville de Cabo Frio, depuis 2000 cette flottille augmente en nombre de navires, atteignant le chiffre de 350 navires en 2010. Il s'agit d'une importante zone de pêche au large de l'état de Rio de Janeiro *(22^o S à 24^o S et 40^o W à 44^o W), la production totale de 2003 à 2012 s'élevant à 2.752 t. L'espèce cible était principalement la coryphène commune capturée à la palangre de surface. Le voilier était également capturé à la palangre de surface et l'albacore à la ligne à main, tandis que la thonine commune était essentiellement capturée par de petits senneurs. L'analyse inclut aussi la distribution des fréquences de taille de la coryphène commune, du voilier, de l'albacore et de la thonine commune de 2003 à 2012.*

RESUMEN

La pequeña flota multiespecífica del Atlántico sudoccidental (Cabo Frío, Río de Janeiro-Estado RJ, Brasil) se compone de pequeños barcos que capturan el 15% de la producción total de Río de Janeiro. Estimulada por la productividad causada por el afloramiento, las instalaciones de desembarque y las industrias de Cabo Frío, desde 2000 esta flota ha ido creciendo en número de barcos, alcanzando los 350 en 2010. Representa una importante zona de pesca en aguas del Estado de Río de Janeiro (22^o S a 24^o S y 40^o W a 44^o W), y la producción total desde 2003 hasta 2012 fue de 2.752. La especie objetivo era principalmente el dorado usando el palangre de superficie. El pez vela se captura también mediante el palangre de superficie, el rabil se captura básicamente con liña de mano y la bacoreta se captura principalmente con pequeños cercos. El análisis incluye también la distribución de la frecuencia de tallas del dorado, el pez vela, el rabil y la bacoreta desde 2003 a 2012.

KEYWORDS

Capture fishing, Fishing gear, Multispecies fisheries, Catch composition, Commercial fishing

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1. Introduction

The small-size fleet of Cabo Frio City, Rio de Janeiro-RJ State, Brazil represented 15% of RJ total yield (Marques *et al*., 2000). The water high productivity, landing facilities around Araruama Lake and exportation industries, Cabo Frio City has about 350 boats of small-size fleet. These boats usually ranging from 12 to 15 meters and under 20 TM, comes from another regions and States. This fleet during the year directs their fishery to different fish species and use variety of equipments, mainly surface longline and hand line with live sardine as bait (Pimenta *et al.,* 2007).

Cabo Frio upwelling gives to the region high fishery productivity (Moreira-Silva, 1970). The oceanographic conditions facilitate the fisherman of this fleet to catch many different species.

The aim of this paper was to characterize the multispecific small-size fleet and analyze mainly the dolphinfish, yellowfin tuna, sailfish, little tuna and another fish fishery caught by Cabo Frio small-size fleet during 2003 to 2012 period.

2. Material and Methods

The statistics data were monthly collected during from 2003 to 2012 at the Cabo Frio Fishing Terminal and fishery companies. The information about gear and boat size was based on interview of fishermen done by graduate student, which registered the, boat name, data, number of fish and weight by specie or group of species.

Length and weight relationship, based on total weight were used for dolphinfish, sailfish, yellowfin tuna and little tuna. The equation used for the grouped sex was as follow: dolphinfish $Wt=0.3x10^{-5}Lt^{3.183}$ (not published); sailfish (Prager et. al., 1995), yellowfin tuna (Caveriviere, 1976) and little tuna (Rodriguez-Roda, 1966).

The analysis was made using the JMP Software (Version 10.0).

The small-size fishery was mainly concentrate off Cabo Frio City, Rio de Janeiro State, between the 22^oS to 24^oS and the 40^oW to 44^oW (Pimenta and Lima 2002). The collected data was based in the previous article as Pimenta *et al.* (2007).

3. Results and Discussion

The analysis was based on 4,276 fishery trips information of 470 small boats basically using five kinds of gears from 2003 to 2012. The gears used were surface longline (SLL), midwater longline (MLL), botton longline (BLL), hand line (HL), botton hand line (BHL), small purse seine (SPS), trap (TRAP), and small gillnet (SGN).
The fishermen used live sardine as bait with hooks gears most of the time.

3.1. Characterization of small-size fleet equipments.

3.1.1. Surface longline (SLL), midwater longline (MLL) and bottom longline (BLL)

The longline is a device that uses a secondary main line and several attached to a hook and swivel. The longline size and number of hooks depend of the boat size and could be used at surface, midwater or bottom according to the fishery target. It can be fixed or drift . The vessel's longline puts the box in a position to launch, spare lines, boxes with live bait, fish box, floats and others things. The launch of longlines according to boat, varies, being done by the stern or the bow.

The surface longline is released in a time immersed depending on the number of hooks used. It has no automation, so the release and hallowing is done manually.

The midwater longline is usually released on the slope with the aid of hydraulic winch.

The bottom line is released on sunrise and collected at sunset. Use about 400 circles hooks. The small fish hooked were used for the bottom longline at night.

3.1.2. Hand line (HL) and bottom hand line (BHL)

The hand line uses natural bait dead or alive, with one or more branch hooks. This gear is used when fishermen are looking for school of fish. Generally 6 to 8 lines per boat, according to the size and number of fishermen. The equipment consists of a nylon line of about 50 meters on their end and put a swivel with another secondary line of a nylon or steel cable to prevent loss of the hook. The fisherman catching the fish when pulls it to the side of the boat, where another fisherman with a stick pulled on board.

The bottom hand line using 6 main lines with 10 to 40 secondary lines and hooks per boat. The fishing operation is performed during the day and the equipment consists of a monofilament line followed by a swivel, attached to the monofilament line with a weight close to the hook. Along the main line are branch lines connected with swivels.

3.1.3. Small purse seine (SPS) and trap (TRAP)

The small purseine consists of several pieces of net without node usually braided nylon mesh from 8 to 12 mm.The approach to the school of fish is made by one side, making up the siege with the rudder to port after helping launch the boat. During the approach of the boat at the closing end of the siege, a cable is passed polyethylene board the trawler when it starts closing the enclosure. It is made at night, with the arrival in the next morning to the port and returning to fishing area in the afternoon. The sets are made close to the beach or rocky shores with a duration which varies with the amount captured from 2 to 6 hours.

The trap is suitable for catching fish and crabs and it has the form of baskets constructed with metal and surrounded by a net with an opening. The traps are placed at the bottom with bait in a single row of 10 cages away from each other by 500 meters and connected by cable to a buoy with a flag that indicates their position on the surface. The process of launching and gathering spends about one hour and the traps stay at place during the day. Complementarily during the night, the crew fish with bottom line composed of braided nylon amended the nylon monofilament by using a main line with many secondary up to 10 hooks. The small fish caught are intended to be bait for the traps on the next day.

3.1.4. Small gillnet (SGN)

A small gillnet consists of a rectangular net positioned vertically in the water. The target species are gilled and it usually operates in half water on the surface, drifting or anchored to the substrate. They are formed by rectangular panels of net connected end, whose length and height vary with the species to be captured. Each piece of net is mounted on two cables, with a top of the cable floats called floats and bottom weights with a number, called the cable leads. The wire cloth is soft and barely visible in the water. The small gillnet stay in the water about 12 hours, and can be placed on the surface, midwater and bottom. The launch is performed by the stern when there is no wind then they are dropped following the direction of the currents.

3.2. Characterization of the multispecific small-size fleet

The total production of the multispecific small fleet based in Cabo Frio City from 2003 to 2012 was 2,752 tons. The 15 top species listed in this study represented 78.7% of yield totaling 2,166 tons. The species were the dolphinfish-DOF (*Coryphaena hippurus);* bigeye tuna-BET (*Thunnus obesus*); albacore-ALB (*Thunnus alalunga*); yellowfin tuna-YFT (*Thunnus albacares*); blackfin tuna-BLF(*Thunnus atlanticus*); skipjack tuna-SKJ (*Katsuwonus pelamis*); little tuna-LTA (*Euthynnus alletteratus*); frigate tuna-FRI (*Auxis thazard*); sailfish-SAI (*Istiophorus platypterus*); swordfish-SWO (*Xiphias gladius*); white marlin-WHT (*Kajikia albida*) and blue marlin-BUM (*Makaira nigricans*); shortfin mako-SMA (*Isurus oxyrinchus*); blue shark-BSH (*Prionace glauca*); tiger shark-TIG (*Galeocerdo cuvier*).

Analyzing fleet of Cabo Frio and Angra dos Reis (RJ) with emphasis on small purse seine between 1996 and 1998, Magro *et al.* (2002) observed from registers of 8,476 landings as much higher species diversity in Cabo Frio than Angra dos Reis. Nevertheless, it was noted a decline in total production of Cabo Frio directly linked to the decline in the number of active boats, which fell from 70 in 1996 to 62 in 1997 and just 50 in 1998, totaling 138 vessels (MAGRO *et al.,* 2002). On the other hand, in the present study data were obtained from 470 boats between 2003 and 2012, involving all fishing gear but possibly showing a growing in number of small fleet in Cabo Frio.

It was observed that between 2003 to 2012 period, the main gear were surface longline-SLL, which represented 63.3% of the total weight caught and hand line-HL with 7.7% (**Figure 1**).

Based in Cabo Frio City it was observed that the small-size fleet was 61.9% ocasionaly; 15.6% were Cabo Frio resident, 12.3% had low dependency and 10.2% had high dependency. Only about 25% remains this fleet in Cabo Frio all year round (**Figure 2**).

The boat sizes distribution was 73.6% between 11 to 15 meters long, 13.2% between 6 to 10 m, 12.4% higher then 16 m and 8% lower then 5 m (**Figure 3**).

Jablonski (1997) analyzed the multispecific fleet of Cabo Frio and Arraial do Cabo (RJ), and between the years 1985 and 1995 the production of Cabo Frio represented on average 17% of total production in the state of Rio de Janeiro. Between 1990 and 1996, the dolphinfish represented only 5% of the total catch in that period when the fleet was headed for sardines (Jablonski, 1997).

Among the species listed in the present study, the dolphinfish was the most frequently captured, totaling 1,428 t and representing 51.8% of the total yield for the hole period. The sailfish reached 250 t (9.1%), the yellowfin tuna 187 t (6.8%) and the little tuna 128 t (4.6%). The total yield by the main species is represented in **Figure 4**.

It could be observed that the dolphinfish was the target species of the fishery, however some may have directed the fleet to the sailfish. The analysis of Itaipava's fleet in southern Brazil between 2001 and 2005 showed that the dolphinfish represented 94% of the total catch from surface longline (Dallagnolo and Andrade, 2008).

The dolphinfish and sailfish were caught almost exclusively by surface longline-SLL (**Figures 5** and **6**). On the other hand yellowfin tuna was captured basically by hand line-HL (**Figure 7**). The little tuna was mostly caught by small purse seine-SPS, nevertheless also surface longline-SLL and small gillnet-SGN (**Figure 8**).

On surface longline-SLL fisheries, the main species were dolphinfish (1.408t - 80.8%) and sailfish (t 249.7 - 14.3%) (**Figure 9**). These data are very different from large scale surface longline, for example the japanese longliners fleet in Brazil, as described by Silva (1994) from 1977 to 1991 that catched 24.7% of bigeye tuna, 20% of yellowfin and just 1% of sailfish. On the other hand, as described on the present study, according to Pimenta *et al.* (2007) the surface longline small fleet of Cabo Frio has the dolphinfish as a target species.

The most of hand line-HL captured were yellowfin tuna (161 t, 75.8%), the blackfin tuna (22.5 t, 10.6%) and also the dolphinfish (8.5 t, 4%) (**Figure 10**).

In the samll purse seine the main species was little tuna (62,2 t, 68,6%), frigate tuna (22,5 t, 24,8%) and skipjack tuna (5,5 t, 6%) (**Figure 11**). Magro *et al.* (2002) studied the small purse seine fishery of Cabo Frio between 1996 and 1998 and observed that the little tuna represented just 6,7% of total capture in 1996, 6,5% in 1997 and 2,6% in 1998. The small purse seine fleet seems to had changed the target species that was sardine on the period studied by Magro et al. (2002).

3.3. Length frequency of size distribution of main species

Length classes of dolphinfish, sailfish, yellowfin tuna and little tuna were shown in **Figures 12**, **13**, **14** and **15**. We observed that the highest frequency of dolphinfish individuals was in the class of 100-105 cm. However, the capture of individuals smaller than 65cm was also representative. Gadoni *et al.* (2011) analyzed the dolphinfish capture off Southern Brazil between 1971 to 2010 and the most important length classes were 91-100 cm and 101-110 cm, quite similar to the present study and showing that the most frequent sizes have not changed too much since 1971. However, another important length class was from 55 to 60 cm, the smallest individuals catched between 2003-2012. According to Beardsley (1967) the size of first maturity is 42.5 cm for males and 35 cm for females from individuals from Florida. Bentivoglio (1988) described this size of 52.8 cm for males and 49-52 cm for females (Gulf of Mexico). Beardsley (1967) also observed that the size class at 100% maturity for females was 55 cm. Perez *et al* (1992) reported the size class at 100% maturity for females from Puerto Rico as 60 cm. So that it is possible to infer that there is a high probability that the smallest dolphinfish individuals were already mature and that is why this species did not show an intense decline along the years, even catching small ones.

The most of specimens captured of sailfish in the period studied were from 160 to 170cm, the yellowfintuna from 110 to 120cm and little tuna had the highest frequency observed between 40 and 45cm.

Figures 16, **17**, **18** and **19** indicate the frequency of capture of different length classes of dolphinfish, sailfish, yellowfin tuna and little tuna at intervals during the period 2003-2012. The species that showed the highest selectivity to the gear was the sailfish, which had the majority of individuals captured in the same class. The other species were captured in different length classes.

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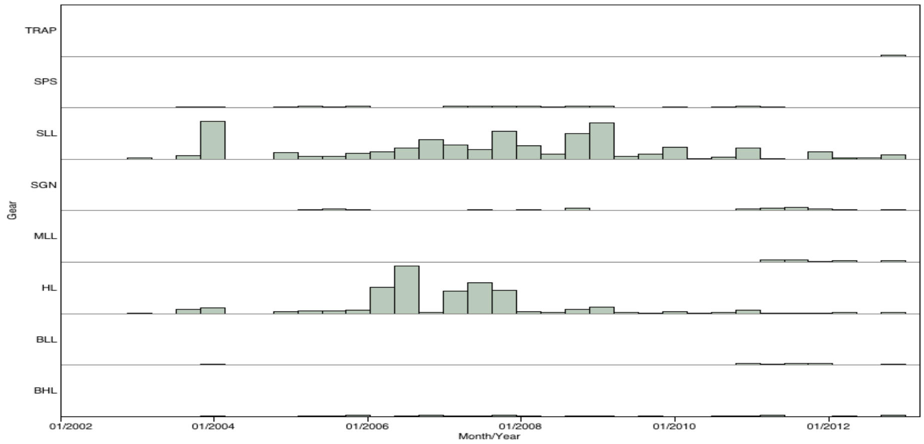

Figure 1. Gear composition of Cabo Frio small-size fleet: SLL (surfice longline), HL (hand line), MLL (midwater longline), BLL (botton longline), BHL (botton hand line), SPS (small purseine), TRAP (trap), and SGN (small gillnet) from 2003-2012.

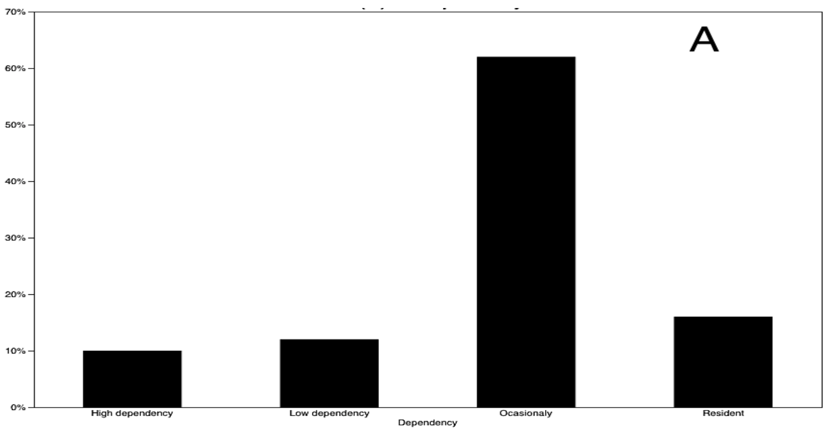

Figure 2. Resident dependency composition of Cabo Frio small-size fleet: high, low, ocasionaly and resident (2003-2012).

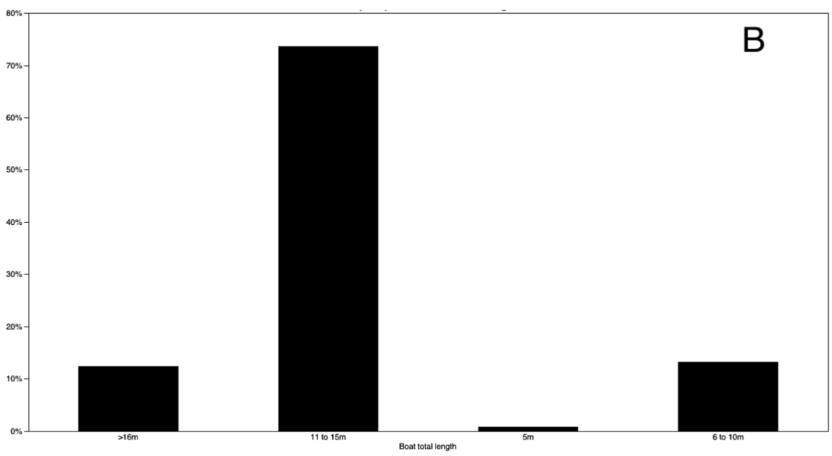

Figure 3. Boat size composition of Cabo Frio small-size fleet: 5 meters long, 6 to 10 m, 11 to 15 m and higher then 16 m (2003-2012).

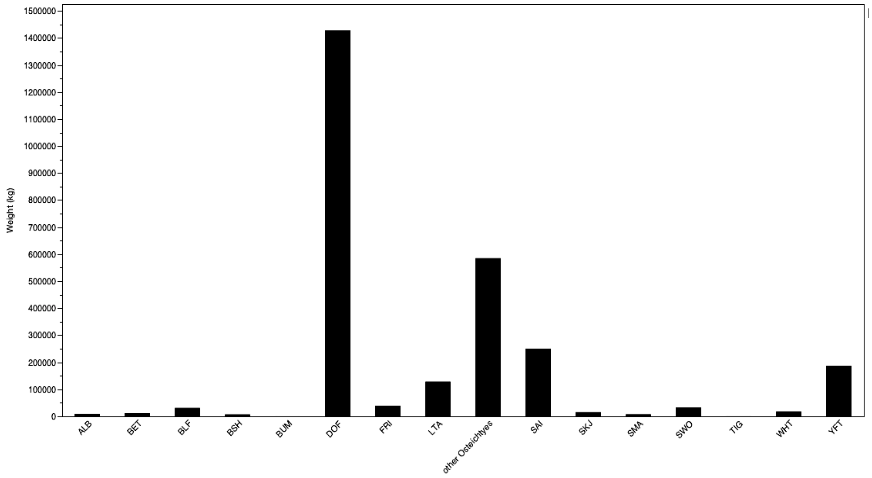

Figure 4. Species composition of Cabo Frio small-size fleet (2003-2012).

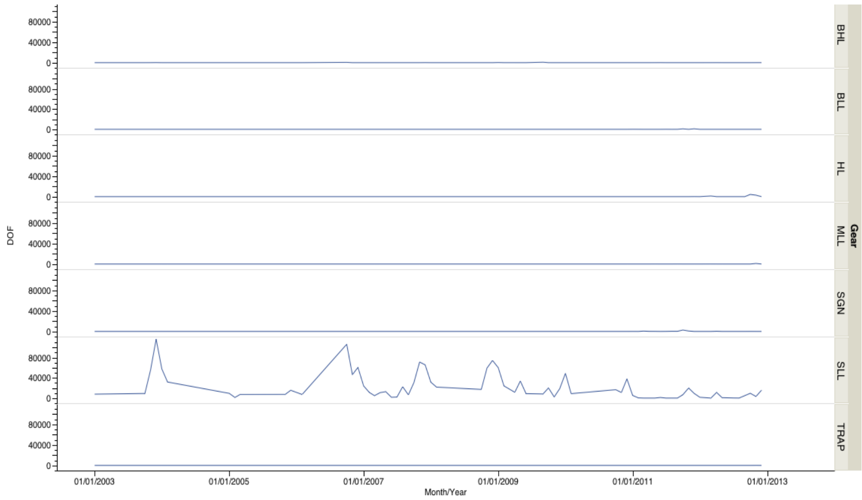

Figure 5. Dolphinfish weight composition by gear and year of Cabo Frio small-size fleet (2003-2012).

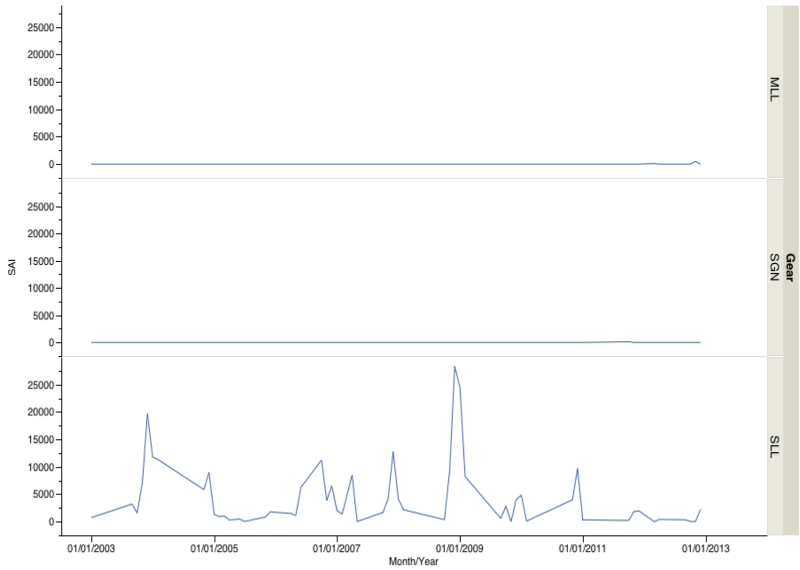

Figure 6. Sailfish weight composition by gear and year of Cabo Frio small-size fleet (2003-2012).

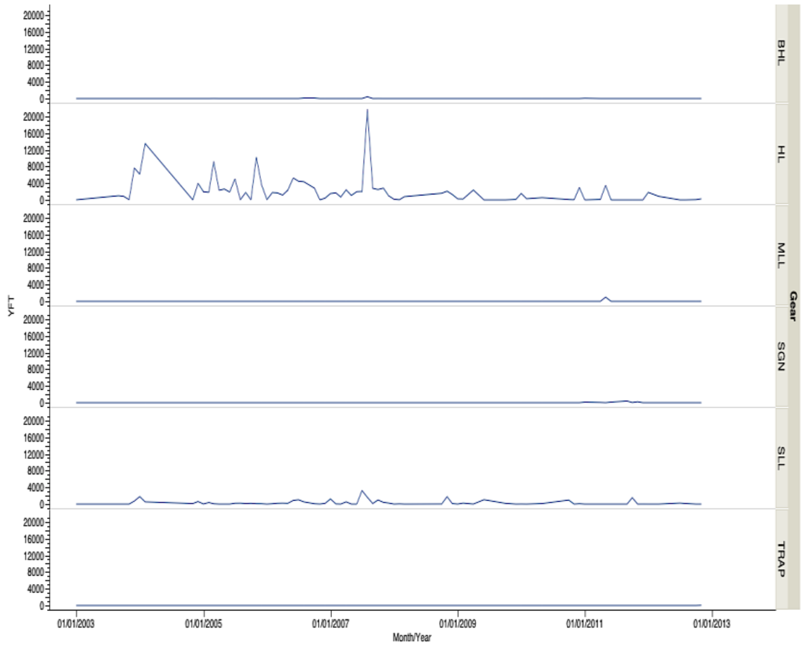

Figure 7. Yellowfin weight composition by gear and year of Cabo Frio small-size fleet (2003-2012).

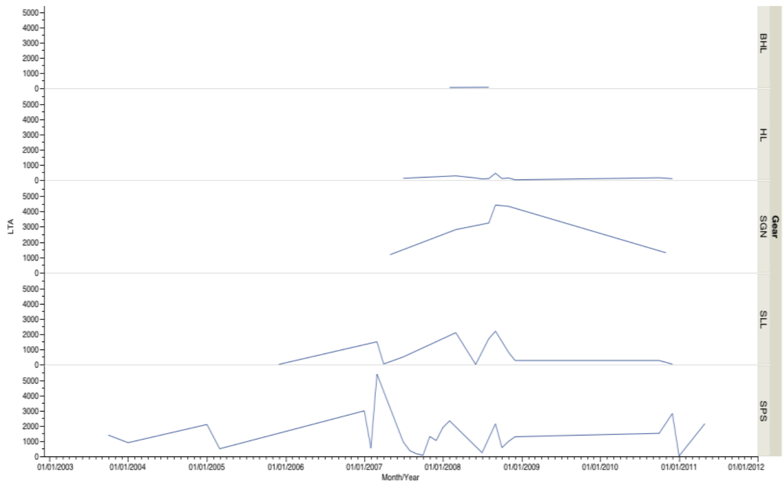

Figure 8. Little tuna weight composition by gear and year of Cabo Frio small-size fleet (2003-2012).

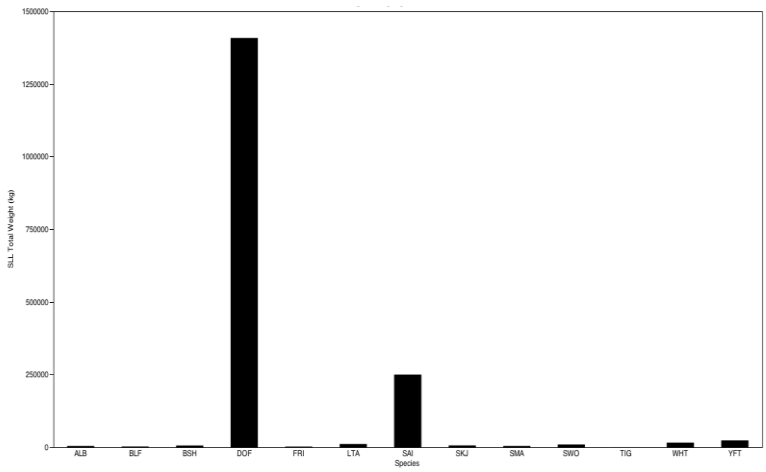

Figure 9. Species weight composition by surface longline-SLL of Cabo Frio small-size fleet (2003-2012).

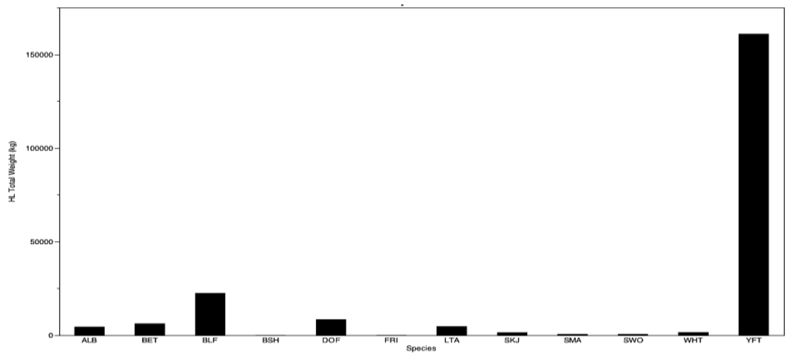

Figure 10. Species weight composition by surface handline-HL of Cabo Frio small-size fleet (2003-2012).

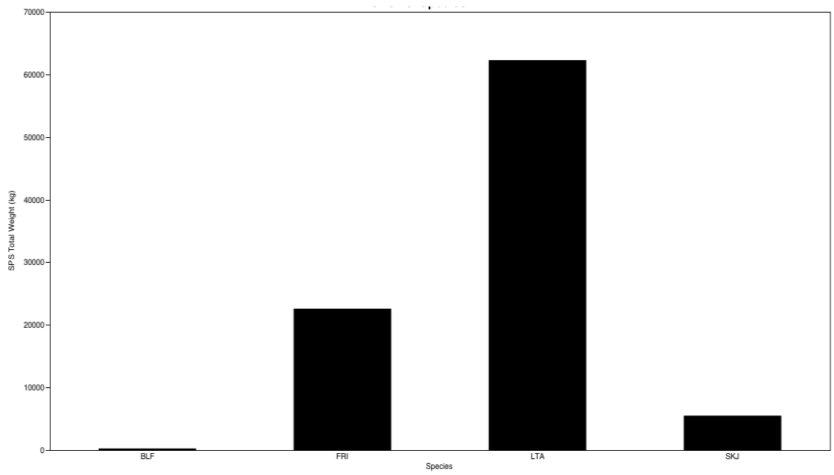

Figure 11. Species weight composition by small purse seine-SPS of Cabo Frio small-size fleet (2003-2012).

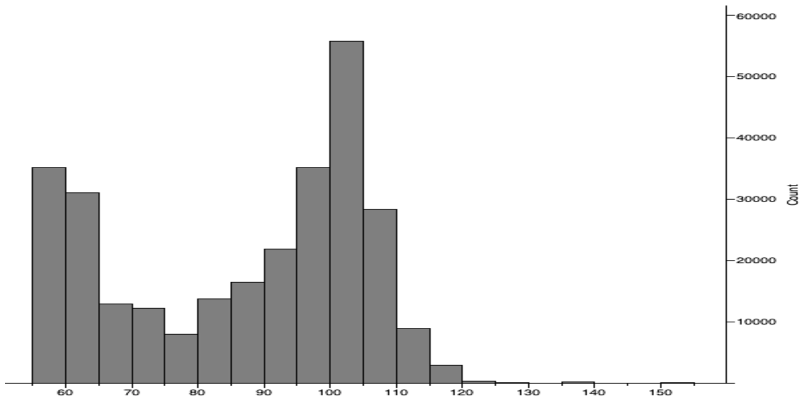

Figure 12. Dolphinfish weight frequency distribution (centimeters) of Cabo Frio small-size fleet (2003-2012).

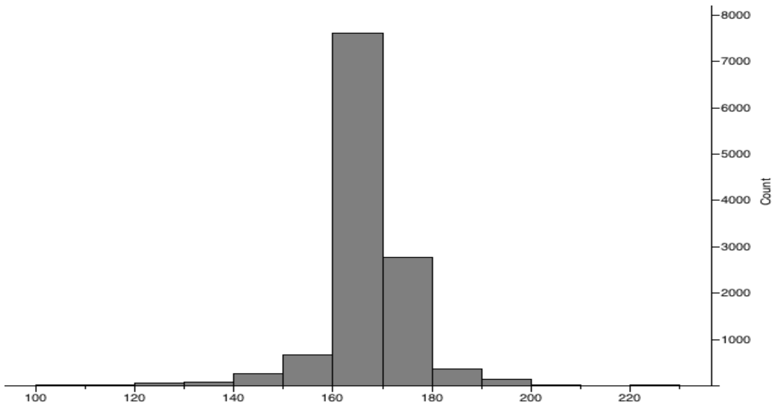

Figure 13. Sailfish weight frequency distribution (centimeters) of Cabo Frio small-size fleet (2003-2012).

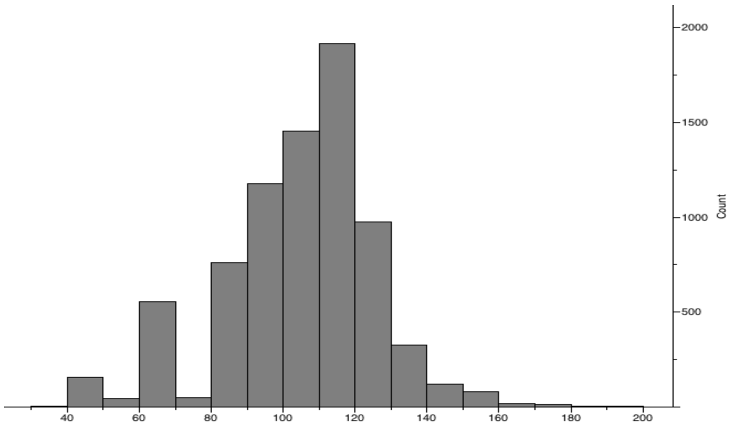

Figure 14. Yellow fin tuna weight frequency distribution (centimeters) of Cabo Frio small-size fleet (2003-2012).

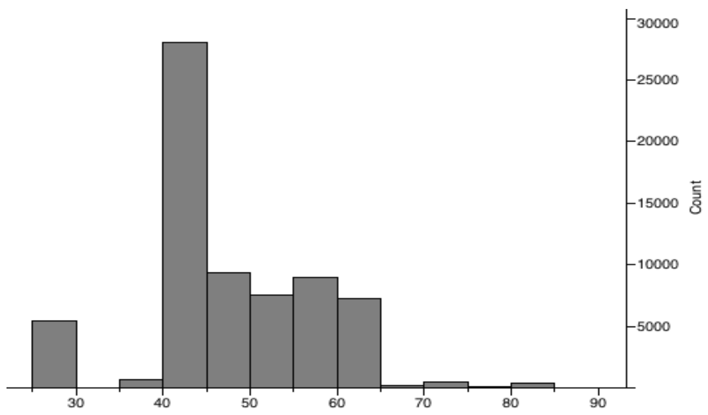

Figure 15. Little tuna weight frequency distribution (centimeters) of Cabo Frio small-size fleet (2003-2012).

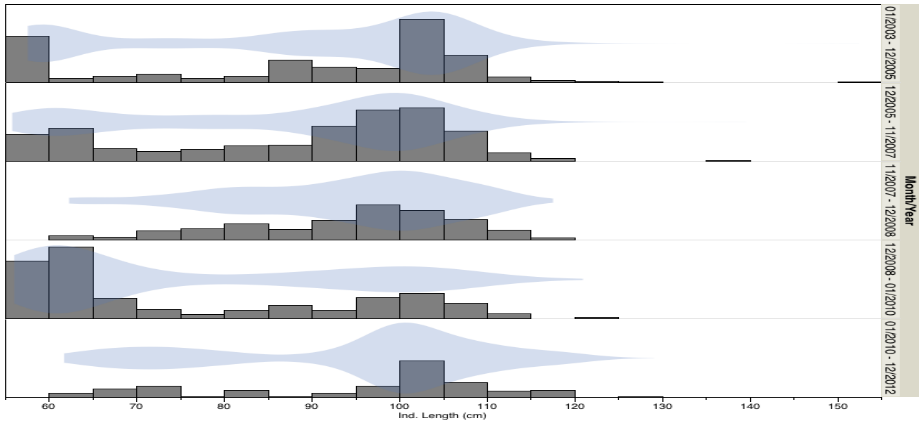

Figure 16. Dolphinfish length frequency distribution (centimeters) by periods of Cabo Frio small-size fleet (2003-2012).

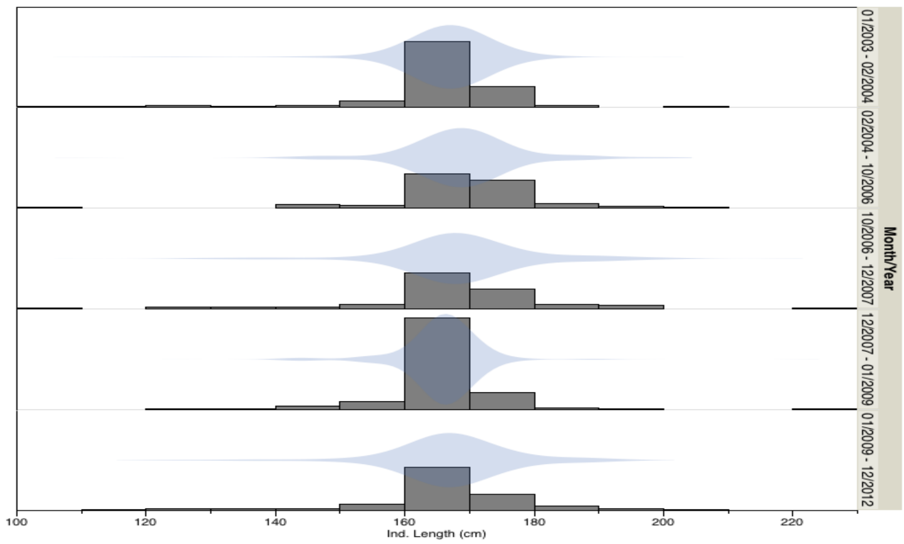

Figure 17. Sailfish length frequency distribution (centimeters) by periods of Cabo Frio small-size fleet (2003-2012).

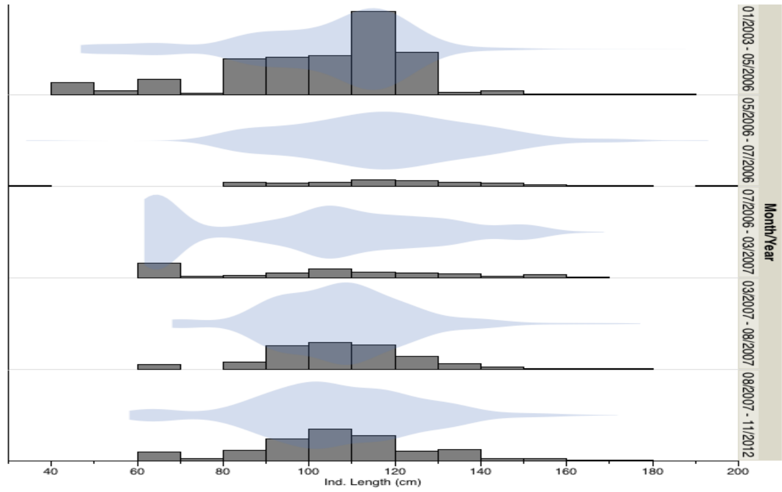

Figure 18. Yellowfin length frequency distribution (centimeters) by periods of Cabo Frio small-size fleet (2003-2012).

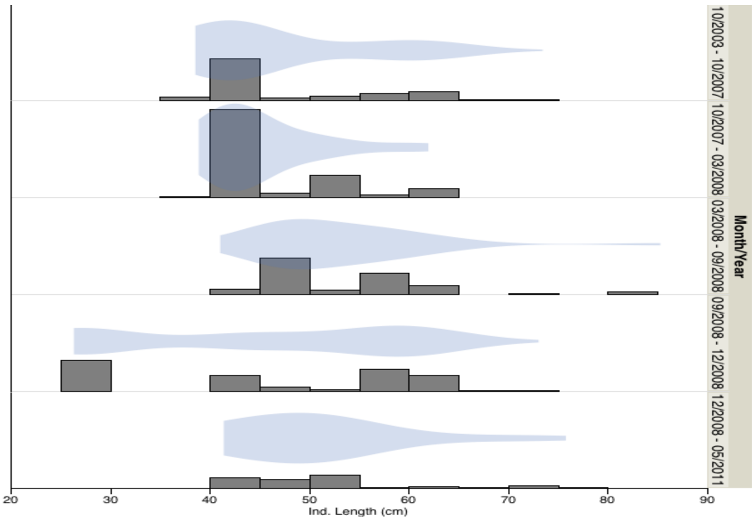

Figure 19. Litthe tuna length frequency distribution (centimeters) by periods of Cabo Frio small-size fleet (2003-2012).

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A SIMULATED CAPTURE-RECAPTURE MODEL FOR ESTIMATING MORTALITY AND STOCK MIXING RATES OF MIGRATORY ATLANTIC FISHES

Matthew V. Lauretta[1]

SUMMARY

A capture-recapture model for estimating the natural mortality, fishing mortality and migration rates of fishes migrating between two regions was outlined and simulation tested. Results were used to evaluate model sensitivity to target and nuisance parameters, and generate estimates of parameter bias and variance across a range of tagging efforts. Four populations were simulated using life-history parameters and fishing mortality estimates from recent assessments of bluefin tuna, yellowfin tuna, albacore, and blue marlin. Simulations revealed that unbiased estimates of natural and fishing mortality can be obtained from conventional tagging programs when coupled with electronic tagging studies that provide accurate estimates of instantaneous migration rates, a handling study to evaluate tagging mortality and tag retention, and tag return information from scientific observer programs, fishing fleet reported tags, or both. When recapture information is provided by fishing fleets exclusively, a high reward tagging study is needed to estimate fleet reporting rates and correct for under-reporting of tagged fish. The framework can be expanded to include age-structure, parameter heterogeneity or overdispersion, or to integrate multispecies or multiple fleet tagging information.

RÉSUMÉ

On a décrit et testé par simulation un modèle de capture-récupération pour estimer la mortalité naturelle, la mortalité par pêche et les taux de migration des poissons migrant entre deux régions. Les résultats ont servi à évaluer la sensibilité du modèle aux paramètres cibles et de nuisance et à créer des estimations des biais et des variances des paramètres sur une gamme d'efforts de marquage. Quatre populations ont été simulées à l'aide de paramètres du cycle vital et d'estimations de la mortalité par pêche provenant de récentes évaluations sur le thon rouge, l'albacore, le germon et le makaire bleu. Les simulations ont révélé que des estimations non-biaisées de la mortalité naturelle et par pêche peuvent être estimées des programmes de marquage conventionnel lorsque ceux-ci sont conjugués à des études de marquage électronique qui fournissent des estimations précises des taux de migration instantanée, une étude de manipulation visant à évaluer la mortalité par marquage et la rétention des marques, et des informations sur la récupération des marques des programmes d'observateurs scientifiques, les marques déclarées par la flottille de pêche, ou les deux. Lorsque les informations sur les récupérations sont exclusivement fournies par les flottilles de pêche, une étude de marquage dotée d'une forte récompense est nécessaire pour estimer les taux de déclaration des flottilles et corriger la sous-déclaration des poissons marqués. Le cadre peut être élargi afin d'englober la structure démographique, l'hétérogénéité ou la surdispersion des paramètres, ou bien afin d'intégrer l'information de marquage plurispécifique ou multi-flottilles.

RESUMEN

Se describe y se prueba mediante simulación un modelo de captura-recaptura para estimar la mortalidad natural, la mortalidad por pesca y las tasas de migración de los peces que migran entre dos regiones. Los resultados se utilizaron para evaluar la sensibilidad del modelo a parámetros objetivo y molestia y para generar estimaciones de la varianza y el sesgo de los parámetros en todo el rango de esfuerzos de marcado. Se simularon cuatro poblaciones utilizando parámetros del ciclo vital y estimaciones de la mortalidad por pesca de evaluaciones recientes de atún rojo, rabil, atún blanco y aguja azul. Las simulaciones

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revelaron que las estimaciones no sesgadas de la mortalidad natural y por pesca pueden obtenerse a través de programas de marcado convencional cuando se unen a estudios de marcado electrónico que proporcionan estimaciones precisas de tasas de migración instantánea, un estudio de manipulación para evaluar la mortalidad por marcado y la retención de marcas y la información sobre marcas recuperadas procedente de programas de observadores científicos, marcas declaradas por la flota pesquera o ambos. Cuando la información sobre recaptura la proporcionan exclusivamente las flotas pesqueras, es necesario un estudio de marcado con recompensas altas es necesario para estimar las tasas de comunicación de la flota y corregir la infracomunicación de los peces marcados. El marco puede ampliarse para incluir información sobre estructura de la edad, heterogeneidad de parámetros o sobredispersión, o para intergrar información de marcado multiespecífica o de múltiples flotas.

KEYWORDS

Tagging, Simulation, Migrations, Natural mortality, Catchability

1. Introduction

Considerable uncertainty exists around the population dynamics and fishing mortality rates of migratory pelagic fishes in the Atlantic Ocean (Patterson et al. 2001, Restrepo et al. 2003, Fromentin and Ravier 2005). Accurate estimates of key life-history parameters, including natural mortality, growth and stock mixing rates are needed for the purposes of improving the accuracy of stock assessments and providing sound scientific advice to international stakeholders (Fromentin 2003, Drew et al. 2006). Estimates of annual fishing mortalities from fishery-independent data sources are needed to validate stock assessment results and reduce scientific uncertainty (NRC 1998, Rose and Cohan 2003). The potential benefits of a carefully designed and implemented capture-recapture study include unbiased estimation of species population dynamics parameters and fishing mortality rates and measures of the uncertainty of these parameters.

Absolute abundance, mortality, growth, and migration rates can often be efficiently estimated using capture-recapture models, and a wealth of information is available on the statistical framework for estimating population dynamics from tagging studies (Pollock et al. 2002, Seber 2002, Williams et al. 2002). In open systems such as the Atlantic Ocean, relatively complex capture-recapture models are required to account for sources of mortality, migration, tag loss, and under-reporting of harvested animals. These parameters are generally confounded, and unbiased parameter estimation from a single tagging study is often not possible. It is therefore necessary to couple information from multiple tagging efforts, each aimed at estimating specific target and nuisance parameters (Pine et al. 2003). Kurota et al. (2009), for example, outlined a sequential tagging model that utilized information from electronic tagging to estimate fishing mortality rates over time from conventional tagging data. They demonstrated the utility of coupling information from multiple tagging efforts, and a similar approach was adopted for this analysis.

I programmed and simulated a statistical capture-recapture model aimed at estimating the natural mortality, fishing mortality, and stock mixing rates of four Atlantic migratory fishes, including bluefin tuna (*Thunnus thynnus*), yellowfin tuna (*Thunnus albacares*), albacore (*Thunnus alalunga*), and blue marlin (*Makaira nigricans*).

Key model components included estimation of handling mortality and conventional tag shedding from handling studies, estimation of instantaneous migration rates from pop-up satellite archival tag data, estimation of reporting rates from high reward tag returns, and estimation of natural and fishing mortality from conventional tag returns by scientific observers or fleet reported tags. Study design, data requirements, and model sensitivity to key parameters are evaluated and discussed.

2. Material and Methods

An open capture-recapture model was simulated to evaluate target and nuisance parameter estimate bias and variation across a range of tagging efforts and assuming different life-history parameters (**Tables 1** and **2**). The model structure was similar to the multi-year cohort tag return model of Polacheck et al. (2006), and using a sequential Bayesian approach similar to Kurota et al. (2009) in which electronic and conventional tag information were assessed sequentially. The model structure differed from that of Polacheck et al. (2006) in that inferences are made from the tagged population, absolute abundance is not estimated directly, instantaneous migration rates between two geographic regions are incorporated, and tagging mortality and tag loss are not assumed to be negligible. Model structure differed from Kurota et al. (2009) in that a single stage-class cohort was assessed; however, the model framework can be expanded to include individual age-classes for estimation of age-specific mortality and migration rates. Posterior migration probabilities from pop-up satellite archival tagging data were used as prior probabilities in a conventional tagging capture-recapture simulation. Natural mortality was treated as a target parameter and was estimated along with catchability. Tagging mortality and tag shedding were treated as nuisance parameters with posterior probabilities estimated from handling studies utilizing conventional or electronic tags. Prior distributions for migration, tagging mortality, and tag shedding rates were assumed to have a binomial error structure based on the number of released animals per tag type and the observed success rates. Conventional tag returns were assumed to be from scientific observer programs with known coverage, or reported by fishing fleets with reporting rate estimated from high reward conventional tags. Additional model assumptions are outlined below:

- The study duration was four years
- The study population occurred within two distinct geographic regions
- A proportion of the population in each region migrated to the other region; migration occurred instantaneously throughout the study period
- Natural mortality occurred instantaneously throughout the study period
- Tagging was conducted by biologists within both study regions during years one through three
- Every tagged individual received a unique ID number
- Tagging events occurred annually during discrete sample periods prior to fishing seasons
- A proportion of tagged fish died as a result of handling and tagging; handling mortality rates were discrete
- A proportion of tagged fish that survived the handling procedure shed their tag; tag shedding rates were discrete
- Fishing occurred in each study region after the annual tagging events
- Fishing effort varied across study regions and years
- The probability of capture (p) was modeled as a function of fishing effort (E) and a gear catchability coefficient (q) defined by the following equation:

$$p = 1 - e^{-qE} = 1 - e^{-F}$$

- Fishing effort within a region and year was uniformly distributed between a defined minimum and maximum so that the observed fishing mortality ($F=qE$) was a uniform random number with set boundaries representative of estimates from recent stock assessments
- A proportion of the catch in each region was scientifically observed for tagged individuals
- All tagged individuals in the scientifically observed catches were recorded
- Tagged individuals captured by fishing fleets were reported imperfectly
- The tag ID, date and study region were recorded upon recapture or were reported by fishing fleets
- All recaptured fish were removed by the fishery, and therefore only one recapture event was possible for each tagged individual

Given the model assumptions, there are a discrete number of possible outcomes (capture histories) for each individual tagged and released within a study region and year. Appendix 1 lists the possible capture histories of fish tagged during years one through three in each region, the definitions of these capture histories, and the associated probabilities. **Table 1** contains a list of the parameters contained within the probability statements and their definitions. Target parameters included the instantaneous natural mortality rate, the capture probability modeled as an exponential function of fishing mortality equal to the product of the fleet catchability coefficient and fishing effort within a region, and the stock mixing rates between region 1 and 2 and vice versa. Nuisance parameters included the discrete handling mortality rate, tag shedding rate, and fleet reporting rates in regions 1 and 2. The fleet reporting rates were equivalent to the proportion of the total catch in each region that is scientifically observed, and these parameters were interchangeable in the model. In either case, the reporting rate parameters represent the proportion of recaptured individuals in each region with tag return information.

Predicted numbers of returned tags per region and year (i.e. number of observations per capture history) were simulated as random deviates from the multinomial probability distribution given the number of conventionally tagged fish released and the probability of each capture history defined in Appendix 1. The log-likelihood (LL) function associated with tag return data from each tagging event was the $\log_e$-transformed multinomial probability mass function given the number of tagged fish released and the probability of each capture history:

$$LL_{R,Y}(x_{1\to k}|N, Pr_{1\to k}) = log_e(N!) - \sum_{i=1}^{k} log_e(x_i!) + \sum_{i=1}^{k}[x_i \cdot log_e(Pr_i)]$$

where,
LL is the log-likelihood value
R is the study region
Y is the study year
N is the number of marked fish released within the study region during a year
x_i is the observed number of tagged fish for each capture history i
Pr_i is the probability of each capture history i
k is the total number of capture histories associated with each tagging event

The total log-likelihood function was the sum of the log-likelihoods of each tagging event across study regions and years:

$$Total\ LL = LL_{1,1} + LL_{2,1} + LL_{1,2} + LL_{2,2} + LL_{1,3} + LL_{2,3}$$

Using this model framework, it was possible to simulate data from a four-year capture-recapture study conducted on a variety of migratory Atlantic fishes representing a range of life histories and supported fisheries, including bluefin tuna, yellowfin tuna, albacore, and blue marlin (**Table 2**). Parameter estimate bias and coefficient of variation across a range of tagging study efforts were evaluated using results from 10,000 iterations per model simulation. Tagging efforts included a low effort scenario (1000 conventional tags per study region per year, 100 high reward tags per study region released in year one, 100 fish held for observation, and 50 pop-up satellite archival tags per region released in year one), medium effort scenario (2000 conventional tags per study region per year, 200 high reward tags per study region released in year one, 200 fish held for observation, and 100 pop-up satellite archival tags per region released in year one), and high effort scenario (5000 conventional tags per study region per year, 500 high reward tags per study region released in year one, 500 fish held for observation, and 200 pop-up satellite archival tags per region released in year one). The statistical code for the model, written in program R, is provided in Appendix 2.

3. Results and Discussion

Model simulations indicated that unbiased estimates of natural mortality and catchability can be acquired from conventional tag return data when accurate estimates of migration rates, tagging mortality, tag shedding, and reporting rates are obtained from coupled tagging studies using pop-up satellite archival, conventional and high reward tags (**Figure 1**). At low tagging effort, natural mortality estimate mean bias ranged from approximately 10% for blue marlin to less than 1% for yellowfin tuna and albacore (**Table 3**). Natural mortality coefficient of variation ranged from 0.82 for blue marlin to 0.15 for yellowfin tuna under the low tagging effort scenario. At high tagging effort, mean natural mortality estimate bias was less than 1% for all four populations. Natural mortality estimate coefficient of variation ranged from 0.44 for blue marlin to 0.07 for yellowfin tuna under the high tagging effort scenario. Catchability estimate mean bias was less than 3% for all populations under all three effort scenarios (**Table 3**). Catchability estimate coefficient of variation was highest for blue marlin and bluefin tuna under the low effort scenario at 0.28, and was less than 0.2 for all other simulated populations and effort scenarios. In general, mortality estimates were less biased and most accurate for species with higher natural and fishing mortality (yellowfin tuna and albacore), and parameter estimates for species with low natural mortality ranged considerably (95% CI of estimate bias = -68 to 60% for bluefin tuna, -80 to 90% bias for blue marlin under the high effort scenario). Catchability was estimated with relatively high accuracy (less than 1% mean bias across populations), and low uncertainty (95% CI of estimates bias was plus or minus 26% or less) for all populations in the high tagging effort model.

The conventional tag capture-recapture model is dependent on accurate information from coupled tagging studies. If estimates of tagging mortality, tag shedding, migration, and reporting rates are biased, then estimates of natural and fishing mortality will be biased. The model framework incorporated parameter estimate uncertainty from multiple studies, with estimated variances assumed to be binomial or multinomial, depending on tag type and study (**Figures 2-5** display the posterior probability distributions used as priors in the mortality estimation model). Migration rates can be estimated from individual movement data of satellite archival tagged fish (e.g., Miller and Andersen 2008). Satellite archival tag duration of 6 months was assumed in the simulation; however, longer tag duration may produce more accurate movement probability estimates with optimal tag duration equal to the study duration. Tagging mortality and tag shedding can be estimated by containment studies utilizing conventional tags or via electronic tag data (Brill et al. 2002, Hightower et al. 2001, Pollock and Pine 2007) and from double-tagging studies (Fabrizio et al. 1999). The former method of estimating release mortality may be preferred since fish can be captured and handled in the same manner as those being released, and electronically tagged individuals may experience different handling procedures, stressors, or modified behavior (e.g., Close et al. 2003). When conventionally tagged fish are recorded by scientific observers, the reporting rate parameters are equal to the proportion of the catch observed in each region. If those proportions are known, then fishing fleet reporting rates can be estimated from observer and fleet reported tag returns without a high reward program. When tag return information is reported by fishing fleets, exclusively, then it is necessary to estimate fleet reporting rates from a high reward tagging study or alternative method.

The model presented here represents a simplistic base model from which more complicated models can be constructed and evaluated based on the known life-histories and fisheries of individual age classes, life history stages or species. The estimated bias and variances for a modeled sample size will vary depending on migration patterns, fishing effort, and other parameters associated with the target species or age class. Regardless, the statistical framework can be applied to a broad range of species, age classes, fishing fleets, and tagging efforts. Under the simple structure presented here, the data requirements are relatively minimal. The first data needed are individual PSAT track data for estimation of instantaneous migration rates between regions and to validate mixing assumptions. The second data required are estimates of tagging mortality and tag loss from a containment study, electronic tag data, or both (Pollock and Pine 2007). The final data requirements include the numbers of conventionally tagged fish released in each region in years 1 through 3, the fleet fishing efforts and catch per region and year, the ID numbers of recaptured fish in scientific samples in each region and year, and the proportions of the catches that are observed for tags in each region and year.

The assumption of permanent migration was inherent in the model. Since conventionally tagged fish were recaptured a maximum of once, it was not possible to document multiple migration events between regions. A fish captured in the region it was tagged was assumed to have remained in the region the entire time, and a fish that migrated was assumed to remain in the new region for the remainder of the study period. If during study implementation, the satellite archival tag information indicated that significant mixing occurs between regions, the model could be restructured to account for return migrations or continuous mixing of individuals. Another key model assumption was discrete tagging and fishing seasons. In the simulation, an average time (t) between tagging and fishing seasons equal to three months was assumed. If tagging and fishing occurred continuously throughout the year, the model should be restructured so that probabilities are based on individual times at large (e.g., Lebreton et al 2009) instead of an average time between capture and recapture events. Additionally, tag return information was modeled for a single fleet, but multiple fleet catch and tag return information could be incorporated to better inform natural and fishing mortality estimates.

The high effort study design is ambitious, with the goal of having over 5,000 fish tagged annually in each study region. Study implementation would likely require a large cooperation amongst biologists and fisherman throughout the range of the populations, and distributing the tagging effort across the entire geographic range is ideal for meeting the assumption that tagged individuals are representative of the study population (Brownie et al. 1985). One example scenario is to distribute the effort across 20 cooperating parties, each with the goal of releasing 250 conventionally tagged individuals within a defined geographic region, as well as 10 satellite tagged individuals, 25 high reward tagged fish, and retaining a number of conventionally tagged individuals for a containment study to estimate handling mortality and tag loss. The logistics of implementing such a large-scale tagging effort requires further discussion and expertise from regional scientists and fisherman.

A multispecies tagging study design provides the benefit of greater efficiency compared to disparate species tagging efforts, and produces measures of community metrics including species composition (Lauretta et al. 2013), richness (Boulinier et al. 1998), and diversity (Nichols 1983). Sampling efforts in each region might focus on tagging multiple species of migratory pelagic fishes so that natural and fishing mortality estimates are acquired for a range of populations. Estimates are likely to be more accurate and precise for species that are regional abundant and can be tagged in greater numbers; therefore, distribution of tagging effort across a large geographic range is ideal for a multispecies tagging program. Lastly, estimation of mortality rates and abundances for pelagic communities can provide insight into the trophic dynamics that structure predator and prey populations, and provide information on how communities, as a whole, respond to harvest and environmental change.

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Table 1. Capture-recapture model parameters and definitions.

Parameter	Definition
M	Instantaneous natural mortality rate
m_{12}	Instantaneous migration rate from region 1 to 2
m_{21}	Instantaneous migration rate from region 2 to 1
T	Discrete handling/tagging mortality rate
s	Discrete tag shedding rate
q	Fleet catchability coefficient
r_1	Observer coverage/Fleet reporting rate region 1
r_2	Observer coverage/Fleet reporting rate region 2
t	time between tagging and fishing events

Table 2. Parameter estimates used in the model simulations of four migratory Atlantic fishes.

	Bluefin tuna	Yellowfin tuna	Albacore	Blue marlin
Natural mortality (M)	0.14	0.70	0.40	0.10
Catchability coefficient (q)	0.0001	0.0001	0.0001	0.0001
Effort (E)	500-1000	3000-4000	4000-5000	500-1000
Fishing mortality (F = qE)	0.05-0.1	0.3-0.4	0.4-0.5	0.05-0.1
Migration rate region 1 to 2 (m_{12})	0.05	0.05	0.01	0.20
Migration rate region 2 to 1 (m_{21})	0.10	0.05	0.01	0.20
Tagging/handling mortality (T)	0.10	0.15	0.20	0.10
Tag shedding (s)	0.05	0.04	0.03	0.05
Observer coverage/reporting rate in region 1 (r_1)	0.10	0.10	0.10	0.10
Observer coverage/reporting rate in region 2 (r_2)	0.10	0.10	0.10	0.10

Table 3. Natural mortality and catchability estimate bias and coefficients of variation.

	Bluefin tuna			Yellowfin tuna			Albacore			Blue marlin		
Effort scenario	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Conventional Tags/Year*Region	1000	2000	5000	1000	2000	5000	1000	2000	5000	1000	2000	5000
Handling Study Tags	100	200	500	100	200	500	100	200	500	100	200	500
High Reward Tags/Region	100	200	500	100	200	500	100	200	500	100	200	500
Electronic Tags/Region	50	100	200	50	100	200	50	100	200	50	100	200
Mean % bias M estimates	5.4	2.4	0.8	0.7	0.4	0.2	-0.2	0.2	-0.1	10.3	2.9	0.7
95LL % bias M estimates	-100	-99	-64	-28	-20	-13	-42	-29	-19	-100	-100	-86
95UL % bias M estimates	155	109	68	32	22	14	41	30	18	210	147	90
CV of M estimates	0.67	0.51	0.33	0.15	0.11	0.07	0.21	0.15	0.09	0.82	0.66	0.44
Mean % bias q estimates	-1.7	-2.8	-3.1	1.6	0.5	0.1	1.0	0.5	0.1	2.2	0.5	0.3
95LL % bias q estimates	-44	-35	-24	-33	-24	-16	-27	-21	-13	-41	-31	-21
95UL % bias q estimates	64	39	22	47	30	18	39	26	16	67	42	26
CV of q estimates	0.28	0.20	0.12	0.20	0.14	0.09	0.17	0.12	0.08	0.28	0.19	0.12

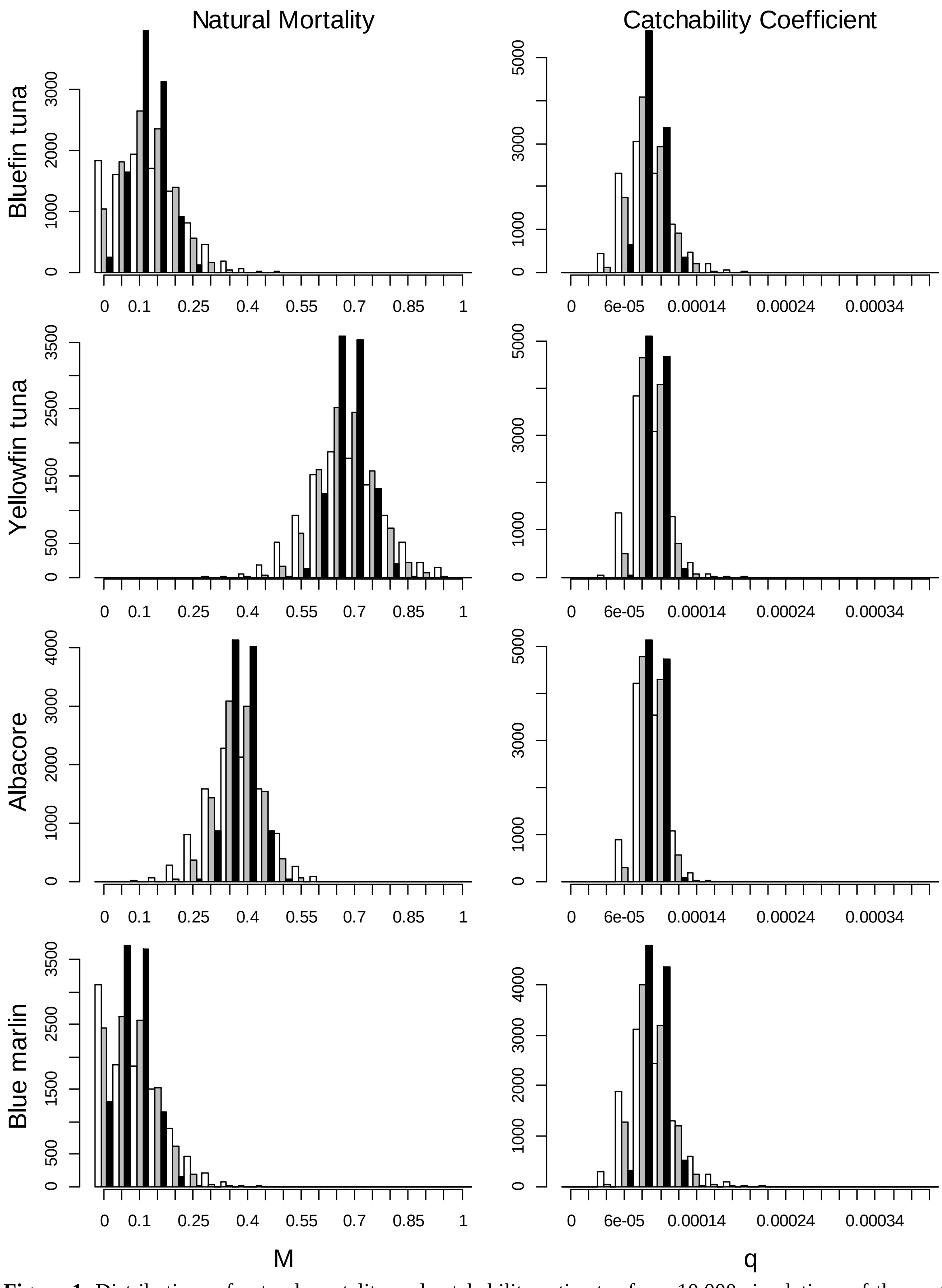

Figure 1. Distributions of natural mortality and catchability estimates from 10,000 simulations of the capture-recapture model under the low effort (white bars), medium effort (gray bars), and high effort (black bars) tagging scenarios.

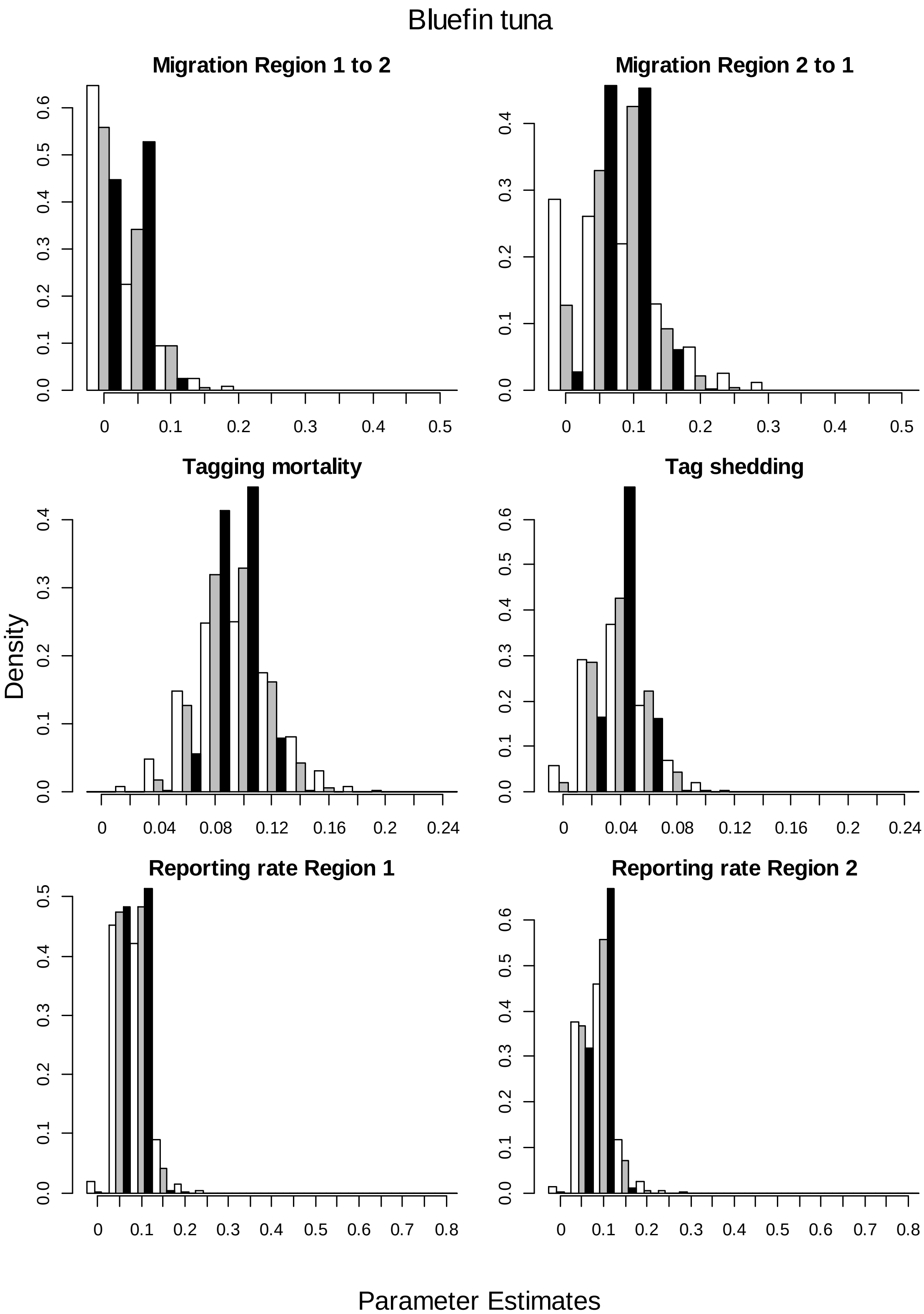

Figure 2. Simulated posterior distributions of migration rates, tag mortality, tag shedding, and reporting rates estimated from coupled tagging studies of bluefin tuna.

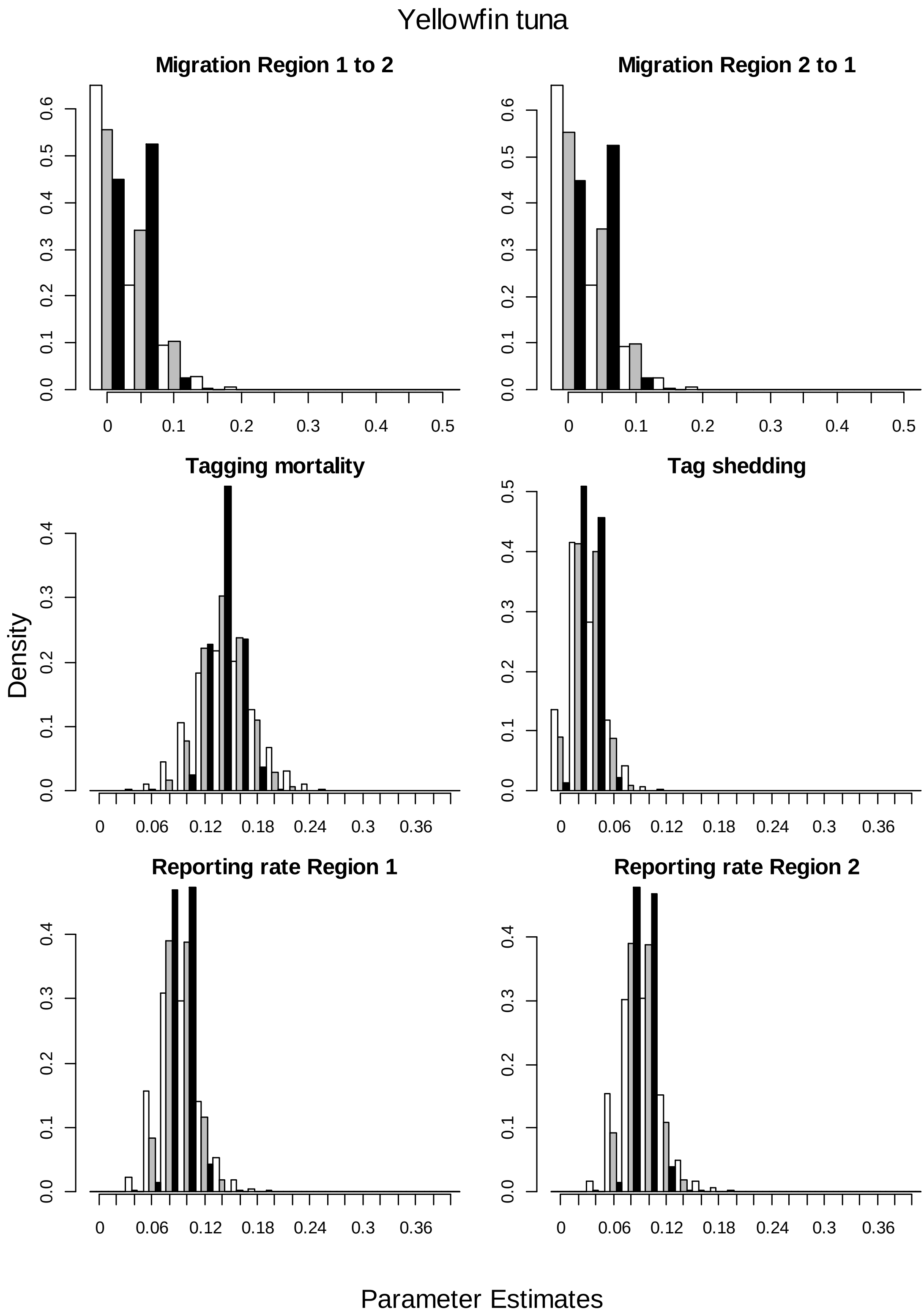

Figure 3. Simulated posterior distributions of migration rates, tag mortality and shedding, and reporting rates estimated from coupled tagging studies of yellowfin tuna.

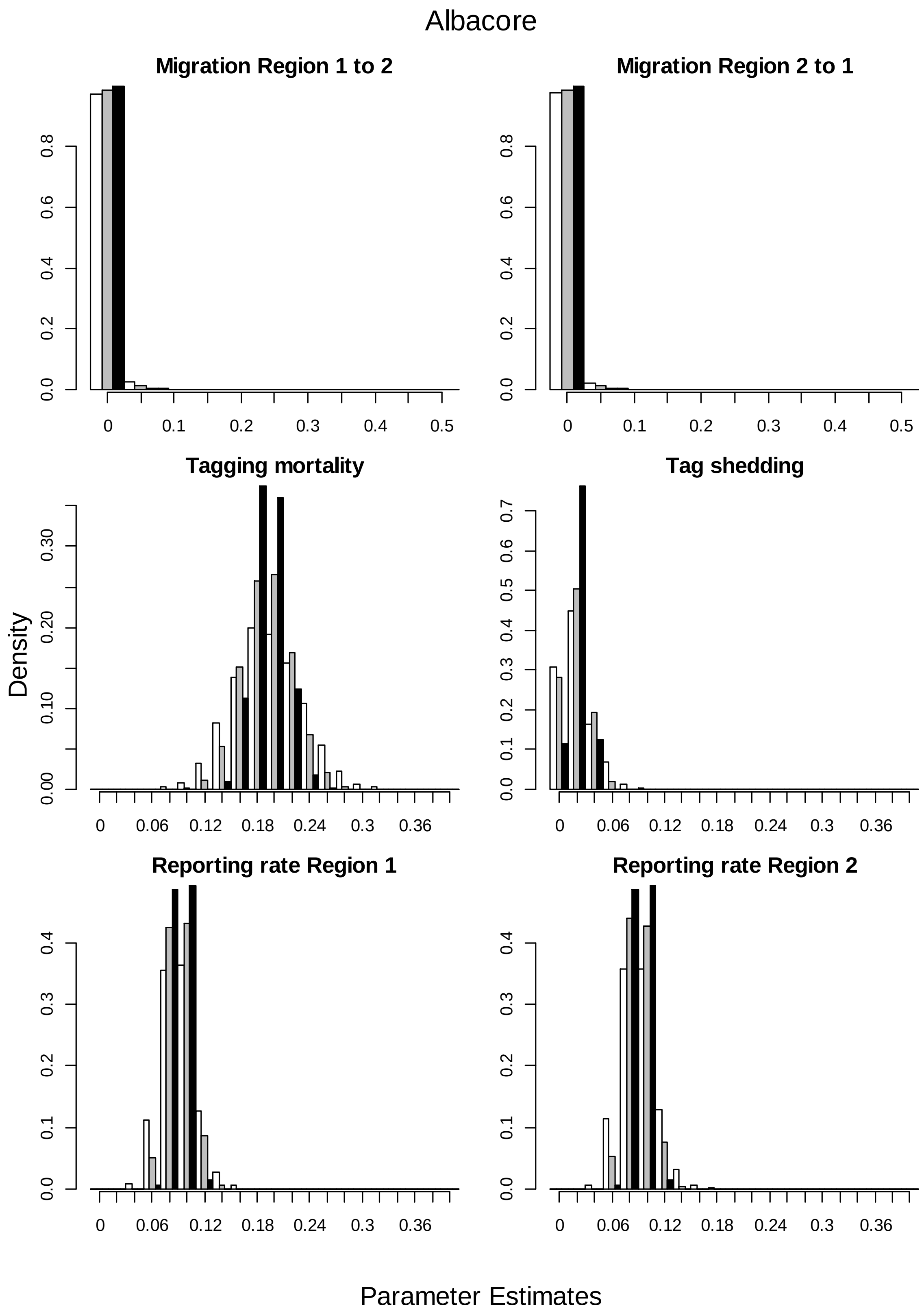

Figure 4. Simulated posterior distributions of migration rates, tag mortality and shedding, and reporting rates estimated from coupled tagging studies of albacore.

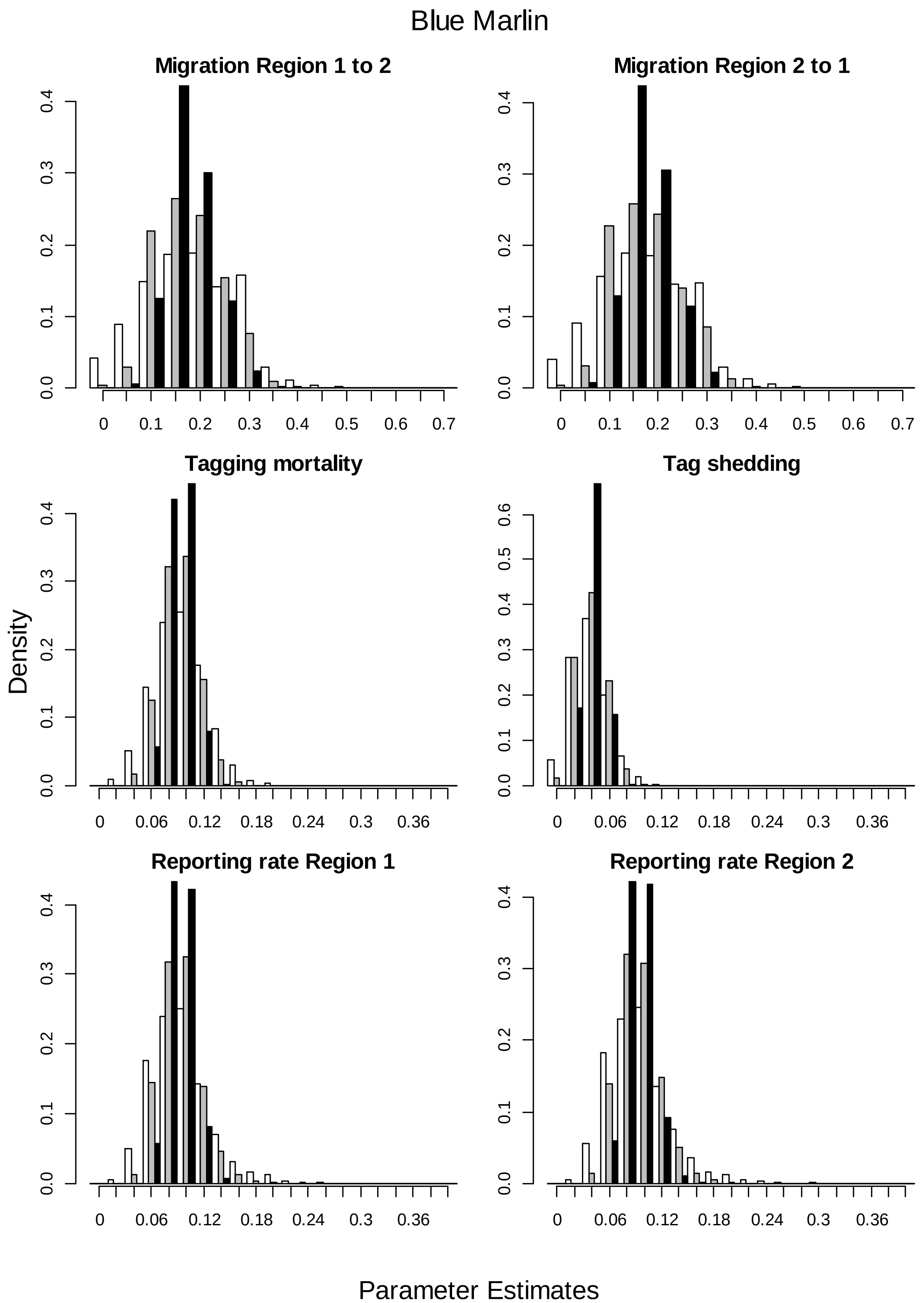

Figure 5. Simulated posterior distributions of migration rates, tag mortality and shedding, and reporting rates estimated from coupled tagging studies of blue marlin.

APPENDIX 1. Definitions of capture-recapture study outcomes (capture histories) and associated probability statements

OUTCOME	DEFINITION
11_1	fish tagged in region 1 during year 1 with tag returned in region 1 during fishing season 1
11_01	fish tagged in region 1 during year 1 with tag returned in region 1 during fishing season 2
11_001	fish tagged in region 1 during year 1 with tag returned in region 1 during fishing season 3
11_0001	fish tagged in region 1 during year 1 with tag returned in region 1 during fishing season 4
11_2	fish tagged in region 1 during year 1 with tag returned in region 2 during fishing season 1
11_02	fish tagged in region 1 during year 1 with tag returned in region 2 during fishing season 2
11_002	fish tagged in region 1 during year 1 with tag returned in region 2 during fishing season 3
11_0002	fish tagged in region 1 during year 1 with tag returned in region 2 during fishing season 4
11_0000	fish tagged in region 1 during year 1 with no tag return information
21_1	fish tagged in region 2 during year 1 with tag returned in region 1 during fishing season 1
21_01	fish tagged in region 2 during year 1 with tag returned in region 1 during fishing season 2
21_001	fish tagged in region 2 during year 1 with tag returned in region 1 during fishing season 3
21_0001	fish tagged in region 2 during year 1 with tag returned in region 1 during fishing season 4
21_2	fish tagged in region 2 during year 1 with tag returned in region 2 during fishing season 1
21_02	fish tagged in region 2 during year 1 with tag returned in region 2 during fishing season 2
21_002	fish tagged in region 2 during year 1 with tag returned in region 2 during fishing season 3
21_0002	fish tagged in region 2 during year 1 with tag returned in region 2 during fishing season 4
21_0000	fish tagged in region 2 during year 1 with no tag return information
12_01	fish tagged in region 1 during year 2 with tag returned in region 1 during fishing season 2
12_001	fish tagged in region 1 during year 2 with tag returned in region 1 during fishing season 3
12_0001	fish tagged in region 1 during year 2 with tag returned in region 1 during fishing season 4
12_02	fish tagged in region 1 during year 2 with tag returned in region 2 during fishing season 2
12_002	fish tagged in region 1 during year 2 with tag returned in region 2 during fishing season 3
12_0002	fish tagged in region 1 during year 2 with tag returned in region 2 during fishing season 4
12_0000	fish tagged in region 1 during year 2 with no tag return information
22_01	fish tagged in region 2 during year 2 with tag returned in region 1 during fishing season 2
22_001	fish tagged in region 2 during year 2 with tag returned in region 1 during fishing season 3
22_0001	fish tagged in region 2 during year 2 with tag returned in region 1 during fishing season 4
22_02	fish tagged in region 2 during year 2 with tag returned in region 2 during fishing season 2
22_002	fish tagged in region 2 during year 2 with tag returned in region 2 during fishing season 3
22_0002	fish tagged in region 2 during year 2 with tag returned in region 2 during fishing season 4
22_0000	fish tagged in region 2 during year 2 with no tag return information
13_001	fish tagged in region 1 during year 3 with tag returned in region 1 during fishing season 3
13_0001	fish tagged in region 1 during year 3 with tag returned in region 1 during fishing season 4
13_002	fish tagged in region 1 during year 3 with tag returned in region 2 during fishing season 3
13_0002	fish tagged in region 1 during year 3 with tag returned in region 2 during fishing season 4
13_0000	fish tagged in region 1 during year 3 with no tag return information
23_001	fish tagged in region 2 during year 3 with tag returned in region 1 during fishing season 3
23_0001	fish tagged in region 2 during year 3 with tag returned in region 1 during fishing season 4
23_002	fish tagged in region 2 during year 3 with tag returned in region 2 during fishing season 3
23_0002	fish tagged in region 2 during year 3 with tag returned in region 2 during fishing season 4
23_0000	fish tagged in region 2 during year 3 with no tag return information

OUTCOME PROBABILITIES

Pr(11_1)=$(1-T)(1-s)\left(e^{-(M+m_{12})t}\right)(1-e^{-qE_{11}})r_1$

Pr(11_01) =$(1-T)(1-s)\left(e^{-(M+m_{12})(t+1)-qE_{11}}\right)(1-e^{-qE_{12}})r_1$

Pr(11_001)=$(1-T)(1-s)\left(e^{-(M+m_{12})(t+2)-q(E_{11}+E_{12})}\right)(1-e^{-qE_{13}})r_1$

Pr(11_0001)=$(1-T)(1-s)\left(e^{-(M+m_{12})(t+3)-q(E_{11}+E_{12}+E_{13})}\right)(1-e^{-qE_{14}})r_1$

Pr(11_2)=$(1-T)(1-s)(e^{-Mt})(1-e^{-m_{12}t})(1-e^{-qE_{21}})r_2$

Pr(11_02)=$(1-T)(1-s)\left(e^{-M(t+1)}\right)(1-e^{-qE_{22}})r_2[(1-e^{-m_{12}t})(e^{-qE_{21}})+(e^{-m_{12}t-qE_{11}})(1-e^{-m_{12}})]$

Pr(11_002) =

$$(1-T)(1-s)\left(e^{-M(t+2)}\right)(1-e^{-qE_{23}})r_2\left[(1-e^{-m_{12}t})\left(e^{-q(E_{21}+E_{22})}\right)+(e^{-m_{12}t-qE_{11}})(1-e^{-m_{12}})(e^{-qE_{22}})+\left(e^{-m_{12}(t+1)-q(E_{11}+E_{12})}\right)(1-e^{-m_{12}})\right]$$

Pr(11_0002)=

$$(1-T)(1-s)\left(e^{-M(t+3)}\right)(1-e^{-qE_{24}})r_2\left[(1-e^{-m_{12}t})\left(e^{-q(E_{21}+E_{22}+E_{23})}\right)+(e^{-m_{12}t-qE_{11}})(1-e^{-m_{12}})\left(e^{-q(E_{22}+E_{23})}\right)+\left(e^{-m_{12}(t+1)-q(E_{11}+E_{12})}\right)(1-e^{-m_{12}})(e^{-E_{23}})+\left(e^{-m_{12}(t+2)-q(E_{11}+E_{12}+E_{13})}\right)(1-e^{-m_{12}})\right]$$

Pr(11_0000)=1

$$-\sum(\mathrm{Pr\_11\_1},\mathrm{Pr\_11\_01},\mathrm{Pr\_11\_001},\mathrm{Pr\_11\_0001},\mathrm{Pr\_11\_2},\mathrm{Pr\_11\_02},\mathrm{Pr\_11\_002},\mathrm{Pr\_11\_0002})$$

Pr(21_2) = $(1-T)(1-s)\left(e^{-(M+m_{21})t}\right)(1-e^{-qE_{21}})r_2$

Pr(21_02)=$(1-T)(1-s)\left(e^{-(M+m_{21})(t+1)-qE_{21}}\right)(1-e^{-qE_{22}})r_2$

Pr(21_002)=$(1-T)(1-s)\left(e^{-(M+m_{21})(t+2)-q(E_{21}+E_{22})}\right)(1-e^{-qE_{23}})r_2$

Pr(21_0002)=$(1-T)(1-s)\left(e^{-(M+m_{21})(t+3)-q(E_{21}+E_{22}+E_{23})}\right)(1-e^{-qE_{24}})r_2$

Pr(21_1)=$(1-T)(1-s)(e^{-Mt})(1-e^{-m_{21}t})(1-e^{-qE_{11}})r_1$

Pr(21_01)=$(1-T)(1-s)\left(e^{-M(t+1)}\right)(1-e^{-qE_{12}})r_1[(1-e^{-m_{21}t})(e^{-qE_{11}})+(e^{-m_{21}t-qE_{21}})(1-e^{-m_{21}})]$

Pr(21_001)=

$$(1-T)(1-s)\left(e^{-M(t+2)}\right)(1-e^{-qE_{13}})r_1\left[(1-e^{-m_{21}t})\left(e^{-q(E_{11}+E_{12})}\right)+(e^{-m_{21}t-qE_{21}})(1-e^{-m_{21}})(e^{-qE_{12}})+\left(e^{-m_{21}(t+1)-q(E_{21}+E_{22})}\right)(1-e^{-m_{21}})\right]$$

Pr(21_0001)=

$$(1-T)(1-s)\left(e^{-M(t+3)}\right)(1-e^{-qE_{14}})r_1\left[(1-e^{-m_{21}t})\left(e^{-q(E_{11}+E_{12}+E_{13})}\right)+(e^{-m_{21}t-qE_{21}})(1-e^{-m_{21}})\left(e^{-q(E_{12}+E_{13})}\right)+\left(e^{-m_{21}(t+1)-q(E_{21}+E_{22})}\right)(1-e^{-m_{21}})(e^{-E_{13}})+\left(e^{-m_{21}(t+2)-q(E_{21}+E_{22}+E_{23})}\right)(1-e^{-m_{21}})\right]$$

Pr(11_0000)=1

$$-\sum(\mathrm{Pr\_21\_1},\mathrm{Pr\_21\_01},\mathrm{Pr\_21\_001},\mathrm{Pr\_21\_0001},\mathrm{Pr\_21\_2},\mathrm{Pr\_21\_02},\mathrm{Pr\_21\_002},\mathrm{Pr\_21\_0002})$$

Pr(12_01)=$(1-T)(1-s)\left(e^{-(M+m_{12})t}\right)(1-e^{-qE_{12}})r_1$

Pr(12_001)=$(1-T)(1-s)\left(e^{-(M+m_{12})(t+1)-qE_{12}}\right)(1-e^{-qE_{13}})r_1$

Pr(12_0001)=$(1-T)(1-s)\left(e^{-(M+m_{12})(t+2)-q(E_{12}+E_{13})}\right)(1-e^{-qE_{14}})r_1$

Pr(12_02)=$(1-T)(1-s)(e^{-Mt})(1-e^{-m_{12}t})(1-e^{-qE_{22}})r_2$

Pr(12_002)=$(1-T)(1-s)\left(e^{-M(t+1)}\right)(1-e^{-qE_{23}})r_2[(1-e^{-m_{12}t})(e^{-qE_{22}})+(e^{-m_{12}t-qE_{12}})(1-e^{-m_{12}})]$

Pr(12_0002)=

$$(1-T)(1-s)\left(e^{-M(t+2)}\right)(1-e^{-qE_{24}})r_2\left[(1-e^{-m_{12}t})\left(e^{-q(E_{22}+E_{23})}\right)+(e^{-m_{12}t-qE_{12}})(1-e^{-m_{12}})(e^{-qE_{23}})+\left(e^{-m_{12}(t+1)-q(E_{12}+E_{13})}\right)(1-e^{-m_{12}})\right]$$

Pr(12_0000)= $1-\sum(\mathrm{Pr\_12\_01},\mathrm{Pr\_12\_001},\mathrm{Pr\_12\_0001},\mathrm{Pr\_12\_02},\mathrm{Pr\_12\_002},\mathrm{Pr\_12\_0002})$

Pr(22_01)=$(1-T)(1-s)(e^{-Mt})(1-e^{-m_{21}t})(1-e^{-qE_{12}})r_1$

Pr(22_001)=$(1-T)(1-s)\left(e^{-M(t+1)}\right)(1-e^{-qE_{13}})r_1[(1-e^{-m_{21}t})(e^{-qE_{12}})+(e^{-m_{21}t-qE_{22}})(1-e^{-m_{21}})]$

Pr(22_0001)=

$$(1-T)(1-s)\left(e^{-M(t+2)}\right)(1-e^{-qE_{14}})r_1\left[(1-e^{-m_{21}t})\left(e^{-q(E_{12}+E_{13})}\right)+(e^{-m_{21}t-qE_{22}})(1-e^{-m_{21}})(e^{-qE_{13}})+\left(e^{-m_{21}(t+1)-q(E_{22}+E_{23})}\right)(1-e^{-m_{21}})\right]$$

Pr(22_02)=$(1-T)(1-s)\left(e^{-(M+m_{21})t}\right)(1-e^{-qE_{22}})r_2$

Pr(22_002)=$(1-T)(1-s)\left(e^{-(M+m_{21})(t+1)-qE_{22}}\right)(1-e^{-qE_{23}})r_2$

Pr(22_0002)=$(1-T)(1-s)\left(e^{-(M+m_{21})(t+2)-q(E_{22}+E_{23})}\right)(1-e^{-qE_{24}})r_2$
Pr(22_0000)= $1-\sum(\text{Pr}\_22\_01, \text{Pr}\_22\_001, \text{Pr}\_22\_0001, \text{Pr}\_22\_02, \text{Pr}\_22\_002, \text{Pr}\_22\_0002)$
Pr(13_001)=$(1-T)(1-s)\left(e^{-(M+m_{12})t}\right)(1-e^{-qE_{13}})r_1$
Pr(13_0001)=$(1-T)(1-s)\left(e^{-(M+m_{12})(t+1)-qE_{13}}\right)(1-e^{-qE_{14}})r_1$
Pr(13_002)=$(1-T)(1-s)(e^{-Mt})(1-e^{-m_{12}t})(1-e^{-qE_{23}})r_2$
Pr(13_0002)=$(1-T)(1-s)\left(e^{-M(t+1)}\right)(1-e^{-qE_{24}})r_2[(1-e^{-m_{12}t})(e^{-qE_{23}})+(e^{-m_{12}t-qE_{13}})(1-e^{-m_{12}})]$
Pr(13_0000)= $1-\sum(\text{Pr}\_13\_001, \text{Pr}\_13\_0001, \text{Pr}\_13\_002, \text{Pr}\_13\_0002)$
Pr(23_001)=$(1-T)(1-s)(e^{-Mt})(1-e^{-m_{21}t})(1-e^{-qE_{13}})r_1$
Pr(23_0001)=$(1-T)(1-s)\left(e^{-M(t+1)}\right)(1-e^{-qE_{14}})r_1[(1-e^{-m_{21}t})(e^{-qE_{13}})+(e^{-m_{21}t-qE_{23}})(1-e^{-m_{21}})]$
Pr(23_002)=$(1-T)(1-s)\left(e^{-(M+m_{21})t}\right)(1-e^{-qE_{23}})r_2$
Pr(23_0002)=$(1-T)(1-s)\left(e^{-(M+m_{21})(t+1)-qE_{23}}\right)(1-e^{-qE_{24}})r_2$
Pr(23_0000)= $1-\sum(\text{Pr}\_23\_001, \text{Pr}\_23\_0001, \text{Pr}\_23\_002, \text{Pr}\_23\_0002)$

APPENDIX 2. Statistical code for the capture-recapture model simulation in program R.

```
### PARAMETERS
M=0.7                         #NATURAL MORTALITY RATE
m12=0.05                      #MIGRATION RATE FROM REGION 1 TO REGION 2
m21=0.05                      #MIGRATION RATE FROM REGION 2 TO REGION 1
T=0.15                        #TAG MORTALITY RATE (DISCRETE)
s=0.05                        #TAG SHED RATE (DISCRETE)

#FLEET 1
q=0.0001                      #FLEET CATCHABILITY COEFFICIENT
r1=0.1                        #PROPORTION OF CATCH IN REGION 1 SCIENTIFICALLY OBSERVED FOR TAGS (OR FLEET REPORTING RATE REGION 1)
r2=0.1                        #PROPORTION OF CATCH IN REGION 2 SCIENTIFICALLY OBSERVED FOR TAGS (OR FLEET REPORTING RATE REGION 2)

E_min=3000
E_max=4000
E11=runif(1,E_min,E_max)      #FISHING EFFORT IN REGION 1 YEAR 1
E12=runif(1,E_min,E_max)      #FISHING EFFORT IN REGION 1 YEAR 2
E13=runif(1,E_min,E_max)      #FISHING EFFORT IN REGION 1 YEAR 3
E14=runif(1,E_min,E_max)      #FISHING EFFORT IN REGION 1 YEAR 4
E21=runif(1,E_min,E_max)      #FISHING EFFORT IN REGION 2 YEAR 1
E22=runif(1,E_min,E_max)      #FISHING EFFORT IN REGION 2 YEAR 2
E23=runif(1,E_min,E_max)      #FISHING EFFORT IN REGION 2 YEAR 3
E24=runif(1,E_min,E_max)      #FISHING EFFORT IN REGION 2 YEAR 4

#TAGGING EFFORT
N11=5000                      #NUMBER OF TAGGED FISH RELEASED IN REGION 1 YEAR 1
N12=N11                       #NUMBER OF TAGGED FISH RELEASED IN REGION 1 YEAR 2
N13=N11                       #NUMBER OF TAGGED FISH RELEASED IN REGION 1 YEAR 3
N21=N11                       #NUMBER OF TAGGED FISH RELEASED IN REGION 2 YEAR 1
N22=N11                       #NUMBER OF TAGGED FISH RELEASED IN REGION 2 YEAR 2
N23=N11                       #NUMBER OF TAGGED FISH RELEASED IN REGION 2 YEAR 3
PSAT1=200                     #NUMBER OF SATTELITE TAGGED FISH RELEASED IN REGION 1
PSAT2=200                     #NUMBER OF SATTELITE TAGGED FISH RELEASED IN REGION 2
PSAT_duration=6/12            #SATTELITE TAG DURATION
Fish_held=500                 #NUMBER OF TAGGED FISH EXAMINED IN HANDLING STUDY
Reward1=500                   #NUMBER OF HIGH REWARD TAGGED FISH RELEASED IN REGION 1
Reward2=500                   #NUMBER OF HIGH REWARD TAGGED FISH RELEASED IN REGION 2
t=3/12                        #TIME BETWEEN TAGGING AND FISHING SEASONS
```

```
### Outcomes and Probabilities_Fish Tagged Year 1 in Region 1
theta=c(M,m12,m21,T,s,q,r1,r2,E11,E12,E13,E14,E21,E22,E23,E24)
CR_Pr11=function(theta)
{
M=theta[1]
m12=theta[2]
m21=theta[3]
T=theta[4]
s=theta[5]
q=theta[6]
r1=theta[7]
r2=theta[8]
E11=theta[9]
E12=theta[10]
E13=theta[11]
E14=theta[12]
E21=theta[13]
E22=theta[14]
E23=theta[15]
E24=theta[16]

### The first number indicates the region the fish was marked, the second indicates the study year, the string following represents the annual capture history
Pr_11_1=(1-T)*(1-s)*exp(-(M+m12)*t)*(1-exp(-q*E11))*r1
Pr_11_01=(1-T)*(1-s)*exp(-(M+m12)*(1+t)-q*E11)*(1-exp(-q*E12))*r1
Pr_11_001=(1-T)*(1-s)*exp(-(M+m12)*(2+t)-q*(E11+E12))*(1-exp(-q*E13))*r1
Pr_11_0001=(1-T)*(1-s)*exp(-(M+m12)*(3+t)-q*(E11+E12+E13))*(1-exp(-q*E14))*r1
Pr_11_2=(1-T)*(1-s)*exp(-M*t)*(1-exp(-m12*t))*(1-exp(-q*E21))*r2
Pr_11_02=(1-T)*(1-s)*exp(-M*(1+t))*(1-exp(-q*E22))*r2*((1-exp(-m12*t))*exp(-q*E21)+exp(-m12*t-q*E11)*(1-exp(-m12*1)))
Pr_11_002=(1-T)*(1-s)*exp(-M*(2+t))*(1-exp(-q*E23))*r2*((1-exp(-m12*t))*exp(-q*(E21+E22))+exp(-m12*t-q*(E11+E22))*(1-exp(-m12*1))+exp(-m12*(1+t)-q*(E11+E12))*(1-exp(-
m12*1)))
Pr_11_0002=(1-T)*(1-s)*exp(-M*(3+t))*(1-exp(-q*E24))*r2*((1-exp(-m12*t))*exp(-q*(E21+E22+E23))+exp(-m12*t-q*(E11+E22+E23))*(1-exp(-m12*1))+exp(-m12*(1+t)-
q*(E11+E12+E23))*(1-exp(-m12*1))+exp(-m12*(2+t)-q*(E11+E12+E13))*(1-exp(-m12*1)))
Pr_11_0000=       T+
                  (1-T)*s+
                  (1-T)*(1-s)*(
                  (1-exp(-M*t))+
                  exp(-(M+m12)*t)*(1-exp(-q*E11))*(1-r1)+
                  exp(-M*t)*(1-exp(-m12*t))*(1-exp(-q*E21))*(1-r2)+

                  exp(-(M+m12)*t-q*E11)*(1-exp(-M*1))+
                  exp(-M*t-q*E21)*(1-exp(-m12*t))*(1-exp(-M*1))+
                  exp(-(M+m12)*(t+1)-q*E11)*(1-exp(-q*E12))*(1-r1)+
                  exp(-M*(t+1)-q*E21)*(1-exp(-m12*t))*(1-exp(-q*E22))*(1-r2)+
                  exp(-M*(t+1)-m12*t-q*E11)*(1-exp(-m12*1))*(1-exp(-q*E22))*(1-r2)+

                  exp(-(M+m12)*(t+1)-q*(E11+E12))*(1-exp(-M*1))+
                  exp(-M*(t+1)-m12*t-q*(E11+E22))*(1-exp(-m12*1))*(1-exp(-M*1))+
                  exp(-M*(t+1)-q*(E21+E22))*(1-exp(-m12*t))*(1-exp(-M*1))+
                  exp(-(M+m12)*(t+2)-q*(E11+E12))*(1-exp(-q*E13))*(1-r1)+
                  exp(-M*(t+2)-q*(E21+E22))*(1-exp(-m12*t))*(1-exp(-q*E23))*(1-r2)+
                  exp(-M*(t+2)-m12*t-q*(E11+E22))*(1-exp(-m12*1))*(1-exp(-q*E23))*(1-r2)+
                  exp(-M*(t+2)-m12*(t+1)-q*(E11+E12))*(1-exp(-m12*1))*(1-exp(-q*E23))*(1-r2)+

                  exp(-(M+m12)*(t+2)-q*(E11+E12+E13))*(1-exp(-M*1))+
                  exp(-M*(t+2)-q*(E21+E22+E23))*(1-exp(-m12*t))*(1-exp(-M*1))+
                  exp(-M*(t+2)-m12*t-q*(E11+E22+E23))*(1-exp(-m12*1))*(1-exp(-M*1))+
                  exp(-M*(t+2)-m12*(t+1)-q*(E11+E12+E23))*(1-exp(-m12*1))*(1-exp(-M*1))+
                  exp(-(M+m12)*(t+3)-q*(E11+E12+E13+E14))+
                  exp(-(M+m12)*(t+3)-q*(E11+E12+E13))*(1-exp(-q*E14))*(1-r1)+
```

```
                    exp(-M*(t+3)-q*(E21+E22+E23+E24))*(1-exp(-m12*t))+
                    exp(-M*(t+3)-q*(E21+E22+E23))*(1-exp(-m12*t))*(1-exp(-q*E24))*(1-r2)+
                    exp(-M*(t+3)-m12*t-q*(E11+E22+E23+E24))*(1-exp(-m12*1))+
                    exp(-M*(t+3)-m12*t-q*(E11+E22+E23))*(1-exp(-m12*1))*(1-exp(-q*E24))*(1-r2)+
                    exp(-M*(t+3)-m12*(t+1)-q*(E11+E12+E23+E24))*(1-exp(-m12*1))+
                    exp(-M*(t+3)-m12*(t+1)-q*(E11+E12+E23))*(1-exp(-m12*1))*(1-exp(-q*E24))*(1-r2)+
                    exp(-M*(t+3)-m12*(t+2)-q*(E11+E12+E13+E24))*(1-exp(-m12*1))+
                    exp(-M*(t+3)-m12*(t+2)-q*(E11+E12+E13))*(1-exp(-m12*1))*(1-exp(-q*E24))*(1-r2)
                    )
probs11=c(Pr_11_1,Pr_11_01,Pr_11_001,Pr_11_0001,Pr_11_2,Pr_11_02,Pr_11_002,Pr_11_0002,Pr_11_0000)
probs11
}

### Outcomes and Probabilities_Fish Tagged Year 1 in Region 2
CR_Pr21=function(theta)
{
M=theta[1]
m12=theta[2]
m21=theta[3]
T=theta[4]
s=theta[5]
q=theta[6]
r1=theta[7]
r2=theta[8]
E11=theta[9]
E12=theta[10]
E13=theta[11]
E14=theta[12]
E21=theta[13]
E22=theta[14]
E23=theta[15]
E24=theta[16]

Pr_21_2=(1-T)*(1-s)*exp(-(M+m21)*t)*(1-exp(-q*E21))*r2
Pr_21_02=(1-T)*(1-s)*exp(-(M+m21)*(1+t)-q*E21)*(1-exp(-q*E22))*r2
Pr_21_002=(1-T)*(1-s)*exp(-(M+m21)*(2+t)-q*(E21+E22))*(1-exp(-q*E23))*r2
Pr_21_0002=(1-T)*(1-s)*exp(-(M+m21)*(3+t)-q*(E21+E22+E23))*(1-exp(-q*E24))*r2
Pr_21_1=(1-T)*(1-s)*exp(-M*t)*(1-exp(-m21*t))*(1-exp(-q*E11))*r1
Pr_21_01=(1-T)*(1-s)*exp(-M*(1+t))*(1-exp(-q*E12))*r1*((1-exp(-m21*t))*exp(-q*E11)+exp(-m21*t-q*E21)*(1-exp(-m21*1)))
Pr_21_001=(1-T)*(1-s)*exp(-M*(2+t))*(1-exp(-q*E13))*r1*((1-exp(-m21*t))*exp(-q*(E11+E12))+exp(-m21*t-q*(E21+E12))*(1-exp(-m21*1))+exp(-m21*(1+t)-q*(E21+E22))*(1-exp(-
m21*1)))
Pr_21_0001=(1-T)*(1-s)*exp(-M*(3+t))*(1-exp(-q*E14))*r1*((1-exp(-m21*t))*exp(-q*(E11+E12+E13))+exp(-m21*t-q*(E21+E12+E13))*(1-exp(-m21*1))+exp(-m21*(1+t)-
q*(E21+E22+E13))*(1-exp(-m21*1))+exp(-m21*(2+t)-q*(E21+E22+E23))*(1-exp(-m21*1)))
Pr_21_0000=         T+
                    (1-T)*s+
                    (1-T)*(1-s)*(
                    (1-exp(-M*t))+
                    exp(-(M+m21)*t)*(1-exp(-q*E21))*(1-r2)+
                    exp(-M*t)*(1-exp(-m21*t))*(1-exp(-q*E11))*(1-r1)+

                    exp(-(M+m21)*t-q*E21)*(1-exp(-M*1))+
                    exp(-M*t-q*E11)*(1-exp(-m21*t))*(1-exp(-M*1))+
                    exp(-(M+m21)*(t+1)-q*E21)*(1-exp(-q*E22))*(1-r2)+
                    exp(-M*(t+1)-q*E11)*(1-exp(-m21*t))*(1-exp(-q*E12))*(1-r1)+
                    exp(-M*(t+1)-m21*t-q*E21)*(1-exp(-m21*1))*(1-exp(-q*E12))*(1-r1)+

                    exp(-(M+m21)*(t+1)-q*(E21+E22))*(1-exp(-M*1))+
                    exp(-M*(t+1)-m21*t-q*(E21+E12))*(1-exp(-m21*1))*(1-exp(-M*1))+
                    exp(-M*(t+1)-q*(E11+E12))*(1-exp(-m21*t))*(1-exp(-M*1))+
                    exp(-(M+m21)*(t+2)-q*(E21+E22))*(1-exp(-q*E23))*(1-r2)+
                    exp(-M*(t+2)-q*(E11+E12))*(1-exp(-m21*t))*(1-exp(-q*E13))*(1-r1)+
                    exp(-M*(t+2)-m21*t-q*(E21+E12))*(1-exp(-m21*1))*(1-exp(-q*E13))*(1-r1)+
                    exp(-M*(t+2)-m21*(t+1)-q*(E21+E22))*(1-exp(-m21*1))*(1-exp(-q*E13))*(1-r1)+

                    exp(-(M+m21)*(t+2)-q*(E21+E22+E23))*(1-exp(-M*1))+
                    exp(-M*(t+2)-q*(E11+E12+E13))*(1-exp(-m21*t))*(1-exp(-M*1))+
                    exp(-M*(t+2)-m21*t-q*(E21+E12+E13))*(1-exp(-m21*1))*(1-exp(-M*1))+
                    exp(-M*(t+2)-m21*(t+1)-q*(E21+E22+E13))*(1-exp(-m21*1))*(1-exp(-M*1))+
                    exp(-(M+m21)*(t+3)-q*(E21+E22+E23+E24))+
                    exp(-(M+m21)*(t+3)-q*(E21+E22+E23))*(1-exp(-q*E24))*(1-r2)+
                    exp(-M*(t+3)-q*(E11+E12+E13+E14))*(1-exp(-m21*t))+
                    exp(-M*(t+3)-q*(E11+E12+E13))*(1-exp(-m21*t))*(1-exp(-q*E14))*(1-r1)+
                    exp(-M*(t+3)-m21*t-q*(E21+E12+E13+E14))*(1-exp(-m21*1))+
                    exp(-M*(t+3)-m21*t-q*(E21+E12+E13))*(1-exp(-m21*1))*(1-exp(-q*E14))*(1-r1)+
                    exp(-M*(t+3)-m21*(t+1)-q*(E21+E22+E13+E14))*(1-exp(-m21*1))+
                    exp(-M*(t+3)-m21*(t+1)-q*(E21+E22+E13))*(1-exp(-m21*1))*(1-exp(-q*E14))*(1-r1)+
                    exp(-M*(t+3)-m21*(t+2)-q*(E21+E22+E23+E14))*(1-exp(-m21*1))+
                    exp(-M*(t+3)-m21*(t+2)-q*(E21+E22+E23))*(1-exp(-m21*1))*(1-exp(-q*E14))*(1-r1)
                    )
probs21=c(Pr_21_1,Pr_21_01,Pr_21_001,Pr_21_0001,Pr_21_2,Pr_21_02,Pr_21_002,Pr_21_0002,Pr_21_0000)
probs21
}

### Outcomes and Probabilities_Fish Tagged Year 2 in Region 1
CR_Pr12=function(theta)
{
M=theta[1]
m12=theta[2]
m21=theta[3]
T=theta[4]
s=theta[5]
q=theta[6]
r1=theta[7]
r2=theta[8]
E11=theta[9]
E12=theta[10]
E13=theta[11]
E14=theta[12]
E21=theta[13]
E22=theta[14]
E23=theta[15]
```

```
E24=theta[16]

Pr_12_01=(1-T)*(1-s)*exp(-(M+m12)*t)*(1-exp(-q*E12))*r1
Pr_12_001=(1-T)*(1-s)*exp(-(M+m12)*(1+t)-q*E12)*(1-exp(-q*E13))*r1
Pr_12_0001=(1-T)*(1-s)*exp(-(M+m12)*(2+t)-q*(E12+E13))*(1-exp(-q*E14))*r1
Pr_12_02=(1-T)*(1-s)*exp(-M*t)*(1-exp(-m12*t))*(1-exp(-q*E22))*r2
Pr_12_002=(1-T)*(1-s)*exp(-M*(1+t))*(1-exp(-q*E23))*r2*((1-exp(-m12*t))*exp(-q*E22)+exp(-m12*t-q*E12)*(1-exp(-m12*1)))
Pr_12_0002=(1-T)*(1-s)*exp(-M*(2+t))*(1-exp(-q*E24))*r2*((1-exp(-m12*t))*exp(-q*(E22+E23))+exp(-m12*t-q*(E12+E23))*(1-exp(-m12*1))+exp(-m12*(1+t)-q*(E12+E13))*(1-
exp(-m12*1)))
Pr_12_0000=1-sum(Pr_12_01,Pr_12_001,Pr_12_0001,Pr_12_02,Pr_12_002,Pr_12_0002)
probs12=c(Pr_12_01,Pr_12_001,Pr_12_0001,Pr_12_02,Pr_12_002,Pr_12_0002,Pr_12_0000)
probs12
}

#Outcomes and Probabilities_Fish Tagged Year 2 in Region 2
CR_Pr22=function(theta)
{
M=theta[1]
m12=theta[2]
m21=theta[3]
T=theta[4]
s=theta[5]
q=theta[6]
r1=theta[7]
r2=theta[8]
E11=theta[9]
E12=theta[10]
E13=theta[11]
E14=theta[12]
E21=theta[13]
E22=theta[14]
E23=theta[15]
E24=theta[16]

Pr_22_01=(1-T)*(1-s)*exp(-M*t)*(1-exp(-m21*t))*(1-exp(-q*E12))*r1
Pr_22_001=(1-T)*(1-s)*exp(-M*(1+t))*(1-exp(-q*E13))*r1*((1-exp(-m21*t))*exp(-q*E12)+exp(-m21*t-q*E22)*(1-exp(-m21*1)))
Pr_22_0001=(1-T)*(1-s)*exp(-M*(2+t))*(1-exp(-q*E14))*r1*((1-exp(-m21*t))*exp(-q*(E12+E13))+exp(-m21*t-q*(E22+E13))*(1-exp(-m21*1))+exp(-m21*(1+t)-q*(E22+E23))*(1-
exp(-m21*1)))
Pr_22_02=(1-T)*(1-s)*exp(-(M+m21)*t)*(1-exp(-q*E22))*r2
Pr_22_002=(1-T)*(1-s)*exp(-(M+m21)*(1+t)-q*E22)*(1-exp(-q*E23))*r2
Pr_22_0002=(1-T)*(1-s)*exp(-(M+m21)*(2+t)-q*(E22+E23))*(1-exp(-q*E24))*r2
Pr_22_0000=1-sum(Pr_22_01,Pr_22_001,Pr_22_0001,Pr_22_02,Pr_22_002,Pr_22_0002)
probs22=c(Pr_22_01,Pr_22_001,Pr_22_0001,Pr_22_02,Pr_22_002,Pr_22_0002,Pr_22_0000)
probs22
}

#Outcomes and Probabilities_Fish Tagged Year 3 in Region 1
CR_Pr13=function(theta)
{
M=theta[1]
m12=theta[2]
m21=theta[3]
T=theta[4]
s=theta[5]
q=theta[6]
r1=theta[7]
r2=theta[8]
E11=theta[9]
E12=theta[10]
E13=theta[11]
E14=theta[12]
E21=theta[13]
E22=theta[14]
E23=theta[15]
E24=theta[16]

Pr_13_001=(1-T)*(1-s)*exp(-(M+m12)*t)*(1-exp(-q*E13))*r1
Pr_13_0001=(1-T)*(1-s)*exp(-(M+m12)*(1+t)-q*E13)*(1-exp(-q*E14))*r1
Pr_13_002=(1-T)*(1-s)*exp(-M*t)*(1-exp(-m12*t))*(1-exp(-q*E23))*r2
Pr_13_0002=(1-T)*(1-s)*exp(-M*(1+t))*(1-exp(-q*E24))*r2*((1-exp(-m12*t))*exp(-q*E23)+exp(-m12*t-q*E13)*(1-exp(-m12*1)))
Pr_13_0000=1-sum(Pr_13_001,Pr_13_0001,Pr_13_002,Pr_13_0002)
probs13=c(Pr_13_001,Pr_13_0001,Pr_13_002,Pr_13_0002,Pr_13_0000)
probs13
}

#Outcomes and Probabilities_Fish Tagged Year 3 in Region 2
CR_Pr23=function(theta)
{
M=theta[1]
m12=theta[2]
m21=theta[3]
T=theta[4]
s=theta[5]
q=theta[6]
r1=theta[7]
r2=theta[8]
E11=theta[9]
E12=theta[10]
E13=theta[11]
E14=theta[12]
E21=theta[13]
E22=theta[14]
E23=theta[15]
E24=theta[16]

Pr_23_001=(1-T)*(1-s)*exp(-M*t)*(1-exp(-m21*t))*(1-exp(-q*E13))*r1
Pr_23_0001=(1-T)*(1-s)*exp(-M*(t+1))*(1-exp(-q*E14))*r1*((1-exp(-m21*t))*exp(-q*E13)+exp(-m21*t-q*E23)*(1-exp(-m21*1)))
Pr_23_002=(1-T)*(1-s)*exp(-(M+m21)*t)*(1-exp(-q*E23))*r2
Pr_23_0002=(1-T)*(1-s)*exp(-(M+m21)*(t+1)-q*E23)*(1-exp(-q*E24))*r2
Pr_23_0000=1-sum(Pr_23_001,Pr_23_0001,Pr_23_002,Pr_23_0002)
probs23=c(Pr_23_001,Pr_23_0001,Pr_23_002,Pr_23_0002,Pr_23_0000)
```

```
probs23
}


#MODEL SIMULATION
trials=100
M_hats=vector(length=trials)
m12_hats=vector(length=trials)
m21_hats=vector(length=trials)
T_hats=vector(length=trials)
s_hats=vector(length=trials)
q_hats=vector(length=trials)
r1_hats=vector(length=trials)
r2_hats=vector(length=trials)

for(i in 1:trials)
                    {
                    E11=runif(1,E_min,E_max)
                    E12=runif(1,E_min,E_max)
                    E13=runif(1,E_min,E_max)
                    E14=runif(1,E_min,E_max)
                    E21=runif(1,E_min,E_max)
                    E22=runif(1,E_min,E_max)
                    E23=runif(1,E_min,E_max)
                    E24=runif(1,E_min,E_max)

                    theta=c(M,m12,m21,T,s,q,r1,r2,E11,E12,E13,E14,E21,E22,E23,E24)

                    #ELECTRONIC TAGGING
                    PSAT1_2=rbinom(1,PSAT1,1-exp(-m12*PSAT_duration))
                    PSAT2_1=rbinom(1,PSAT2,1-exp(-m21*PSAT_duration))
                    m12_hat=-log(1-PSAT1_2/PSAT1)/PSAT_duration
                    m21_hat=-log(1-PSAT2_1/PSAT2)/PSAT_duration

                    #HANDLING STUDY
                    Alive=rbinom(1,Fish_held,(1-T))
                    Alive_tagged=rbinom(1,Alive,(1-s))
                    T_hat=1-Alive/Fish_held
                    s_hat=1-Alive_tagged/Alive

                    #REPORTING STUDY
                    Rewards1=rmultinom(1,Reward1,c(CR_Pr11(theta)[1:4]/r1,CR_Pr11(theta)[5:8]/r2,1-sum(CR_Pr11(theta)[1:4]/r1,CR_Pr11(theta)[5:8]/r2)))[1:8]
                    Rewards2=rmultinom(1,Reward2,c(CR_Pr21(theta)[1:4]/r1,CR_Pr21(theta)[5:8]/r2,1-sum(CR_Pr21(theta)[1:4]/r1,CR_Pr21(theta)[5:8]/r2)))[1:8]

                    #SIMULATED RECAPTURE DATA
                    Returns11=rmultinom(1,N11,CR_Pr11(theta))[1:8]
                    Returns21=rmultinom(1,N21,CR_Pr21(theta))[1:8]
                    Returns12=rmultinom(1,N12,CR_Pr12(theta))[1:6]
                    Returns22=rmultinom(1,N22,CR_Pr22(theta))[1:6]
                    Returns13=rmultinom(1,N13,CR_Pr13(theta))[1:4]
                    Returns23=rmultinom(1,N23,CR_Pr23(theta))[1:4]

                    #Estimated reporting rates
                    r1_hat=(sum(Returns11)/N11)/(sum(Rewards1)/Reward1)
                    r2_hat=(sum(Returns21)/N21)/(sum(Rewards2)/Reward2)

                    #Parameter starting values
                    M_logit=-1
                    m12_logit=log(m12_hat/(1-m12_hat))
                    m21_logit=log(m21_hat/(1-m21_hat))
                    s_logit=log(s_hat/(1-s_hat))
                    T_logit=log(T_hat/(1-T_hat))
                    q_logit=-8
                    r1_logit=log(r1_hat/(1-r1_hat))
                    r2_logit=log(r2_hat/(1-r2_hat))

                    #LOG-LIKELIHOOD ESTIMATION
                    theta2=c(M_logit,q_logit)
                    MLE=function(theta2)
                              {
                              M=1/(1+exp(-theta2[1]))
                              m12=max(1/(1+exp(-m12_logit)),0.000001)
                              m21=max(1/(1+exp(-m21_logit)),0.000001)
                              s=max(1/(1+exp(-s_logit)),0.000001)
                              T=max(1/(1+exp(-T_logit)),0.000001)
                              q=1/(1+exp(-theta2[2]))
                              r1=max(1/(1+exp(-r1_logit)),0.000001)
                              r2=max(1/(1+exp(-r2_logit)),0.000001)

                              obs11=c(Returns11,N11-sum(Returns11))
                              obs21=c(Returns21,N21-sum(Returns21))
                              obs12=c(Returns12,N12-sum(Returns12))
                              obs22=c(Returns22,N22-sum(Returns22))
                              obs13=c(Returns13,N13-sum(Returns13))
                              obs23=c(Returns23,N23-sum(Returns23))

                              probs11=CR_Pr11(theta=c(M,m12,m21,T,s,q,r1,r2,E11,E12,E13,E14,E21,E22,E23,E24))
                              probs21=CR_Pr21(theta=c(M,m12,m21,T,s,q,r1,r2,E11,E12,E13,E14,E21,E22,E23,E24))
                              probs12=CR_Pr12(theta=c(M,m12,m21,T,s,q,r1,r2,E11,E12,E13,E14,E21,E22,E23,E24))
                              probs22=CR_Pr22(theta=c(M,m12,m21,T,s,q,r1,r2,E11,E12,E13,E14,E21,E22,E23,E24))
                              probs13=CR_Pr13(theta=c(M,m12,m21,T,s,q,r1,r2,E11,E12,E13,E14,E21,E22,E23,E24))
                              probs23=CR_Pr23(theta=c(M,m12,m21,T,s,q,r1,r2,E11,E12,E13,E14,E21,E22,E23,E24))

                              -sum(dmultinom(obs11,prob=probs11,log=T))-sum(dmultinom(obs21,prob=probs21,log=T))-sum(dmultinom(obs12,prob=probs12,log=T))-
sum(dmultinom(obs22,prob=probs22,log=T))-sum(dmultinom(obs13,prob=probs13,log=T))-sum(dmultinom(obs23,prob=probs23,log=T))
                              }

                    fit=optim(theta2,MLE)
                    fit

                    M_hats[i]=1/(1+exp(-fit$par[1]))
```

```
			m12_hats[i]=m12_hat
			m21_hats[i]=m21_hat
			T_hats[i]=T_hat
			s_hats[i]=s_hat
			q_hats[i]=1/(1+exp(-fit$par[2]))
			r1_hats[i]=r1_hat
			r2_hats[i]=r2_hat
			}

layout(matrix(c(0,1,2,0,3,4,0,5,6,0,7,8,0,0,0),nrow=5,ncol=3,byrow=T),widths=c(1,5,5),heights=c(5,5,5,5,1))
par(mai=c(0.3,0.1,0.2,0.1))
hist((M_hats-M)/M*100,col=8,xlim=c(-250,250),main='Natural Mortality',breaks=10)
hist((q_hats-q)/q*100,col=8,xlim=c(-250,250),main='Gear Catchability',breaks=10)
hist((m12_hats-m12)/m12*100,col=8,xlim=c(-250,250),main='Migration Region 1 to 2',breaks=10)
hist((m21_hats-m21)/m21*100,col=8,xlim=c(-250,250),main='Migration Region 2 to 1',breaks=10)
hist((s_hats-s)/s*100,col=8,xlim=c(-250,250),main='Tag Shedding',breaks=10)
hist((T_hats-T)/T*100,col=8,xlim=c(-250,250),main='Tagging Mortality',breaks=10)
hist((r1_hats-r1)/r1*100,col=8,xlim=c(-250,250),main='Reporting Rate Region 1',breaks=10)
hist((r2_hats-r2)/r2*100,col=8,xlim=c(-250,250),main='Reporting Rate Region 2',breaks=10)
mtext('Percent Bias',1,outer=TRUE,line=-2)

M_bias=mean((M_hats-M)/M)*100
LL_M_bias=quantile((M_hats-M)/M*100,0.025)
UL_M_bias=quantile((M_hats-M)/M*100,0.975)
M_CV=sd(M_hats)/mean(M_hats)
q_bias=mean((q_hats-q)/q)*100
LL_q_bias=quantile((q_hats-q)/q*100,0.025)
UL_q_bias=quantile((q_hats-q)/q*100,0.975)
q_CV=sd(q_hats)/mean(q_hats)
list(M_bias=M_bias,CI_M_bias=paste(round(LL_M_bias,0),"to",round(UL_M_bias,0)),M_CV=M_CV,q_bias=q_bias,CI_q_bias=paste(round(LL_q_bias,0),"to",round(UL_q_bias,0)),
q_CV=q_CV)

#results=cbind(M_hats,m12_hats,m21_hats,T_hats,s_hats,q_hats,r1_hats,r2_hats)
#write.csv(results,'C:/users/mlauretta/desktop/YFT_High.csv')
```

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RAPPORT RELATIF A LA RECUPERATION ET L'ANALYSE DES SERIES HISTORIQUES DE DONNEES TACHE II DES THONIDES MINEURS EXPLOITES AU MAROC

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SUMMARY

This paper aims at recovering historical SMT datasets exploited in Morocco, and currently unavailable in the ICCAT database. These data were recovered, processed and analyzed for the 1995-2011 period for coastal and artisanal fishing and for the 1984-2011 period for trap fisheries. The quality of these data recovered was statistically verified for the entire period. Regarding compliance of recovered data (Task II) to Task I statistics, dataset analysis has shown a slight difference for the 1998-2011 period, and therefore Task I statistics would require a partial revision.

RESUME

Le présent travail consiste à récupérer des jeux de données historiques sur les thonidés mineurs exploités au Maroc, ne figurant pas actuellement dans la base de données de l'ICCAT. Ces données ont été récupérées, traitées et analysées pour la période 1995- 2011 concernant la pêche côtière et artisanale et pour la période 1984- 2011 pour la pêche aux madragues. La qualité de ces données récupérées a été statistiquement vérifiée pour toute la période. En ce qui concerne la conformité des données récupérées (Tache 2) aux statistiques Tâche I, l'analyse de jeux de données a montré une légère différence pour la période 1998-2011, ce qui nécessiterait une révision partielle des statistiques Tâche I.

RESUMEN

En este documento se recuperan dos conjuntos de datos históricos sobre los pequeños túnidos explotados en Marruecos, que no figuran actualmente en la base de datos de ICCAT. Estos datos han sido recuperados, tratados y analizados, y los del periodo 1995-2011 se refieren a la pesca costera y artesanal, los del periodo 1984-2011 se refieren a la pesca con almadrabas. La calidad de los datos recuperados ha sido estadísticamente verificada en todo el periodo. Respecto a la conformidad de los datos recuperados (Tarea II) a las estadísticas de Tarea I, el análisis de los conjuntos de datos ha mostrado una ligera diferencia para el periodo 1998-2011, que necesitaría una revisión parcial de las estadísticas de Tarea I.

KEYWORDS

Fishery statistics, Sampling, Artisanal Fisheries, Small tunas species

1. Introduction

Au Maroc, une dizaine d'espèces de thonidés mineurs sont recensées dont la bonite à dos rayé (*Sarda sarda*), l'auxide (*Auxis thazard)* et la thonine commune (*Euthynnus alletteratus*) demeurent les espèces les plus fréquemment débarquées. A noter que l'auxide (*Auxis thazard)* pourrait inclure des prises de bonitou (*Auxis rochei*). (ICCAT, 2012).

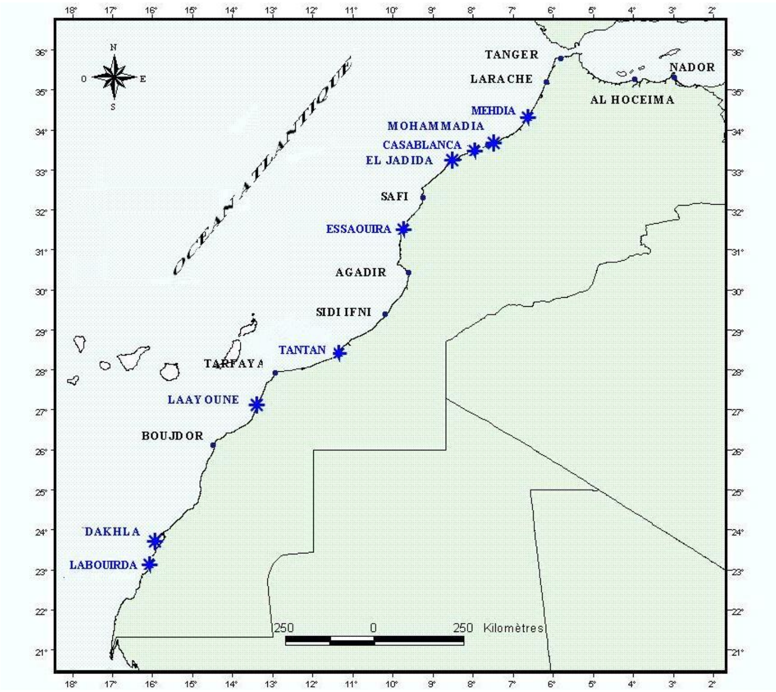
Ces espèces sont exploitées en majorité par des unités côtières (fileyeurs, ligneurs et senneurs) qui sont des unités de pêche ayant un tonnage de jauge brut (TJB) supérieur à 2 tonneaux. Elles sont également pêchées par les barques artisanales dont le TJB ne dépasse pas 2 tonneaux et qui utilisent une multitude d'engins de pêche. Ces flottilles sont distribuées le long du littoral marocain couvrant ainsi les deux façades maritimes atlantique et méditerranéenne. Les débarquements sont effectués au niveau des ports, des villages de pêcheurs, des points de débarquement aménagés et des sites de pêches non aménagés.

2. Description complète du travail accompli

La récupération des séries historiques des données de capture et de l'effort relatives aux thonidés mineurs, ont été réalisées au niveau de huit principaux ports et un site de débarquement de ces espèces en Atlantique marocain appartenant à quatre régions : Dakhla- Labouirda, Laayoune-Tantan, Moulay Bouselham- Essaouira et Tanger-Larache. Ce travail de récupération des séries de données a concerné la période 1995- 2011 pour la pêche côtière et artisanale et la période 1984-2011 pour les douze madragues marocaines dans la région de Tanger-Larache (**Figure 1 et Tableaux 1 et 2**).

Au cours de cette étude, il a été procédé à :

- La récupération des séries historiques de données de capture et de l'effort relatives aux thonidés mineurs. Ces données proviennent des délégations régionales de l'Office National des Pêches (ONP) sous format électronique, pour la pêche côtière et artisanale et des délégations des pêches maritimes et des concessionnaires des madragues sous format papier (fiches et registres), pour la pêcherie des madragues ; (cf. **Tableaux 1 et 2**)
- La saisie des fiches statistiques relatives aux thonidés mineurs exploités par les madragues. Ces fiches donnent le bilan d'exploitation de chacune des 12 madragues, c'est-à-dire les quantités capturées par espèce en poids et en nombre. Elles indiquent également la date du calage et de la levée de chaque madrague. Cette information a été utilisée pour calculer l'effort de pêche;
- La réalisation des enquêtes de terrains, par segment de pêche, pour déterminer les engins utilisés pour la pêche des thonidés mineurs. En effet, les principaux engins de pêche utilisés sont : le bonitard (Filet maillant dérivant), le filet maillant simple, le filet maillant à courbine et le filet trémail, la madrague, la palangre, la ligne à main, la ligne de traine et la senne tournante; (ICCAT, 2008)
- La standardisation des fichiers statistiques, à savoir la standardisation des noms des bateaux, leurs matricules, leurs segments, les dates et les noms des espèces. ;
- La vérification de la qualité des données par des méthodes statistiques ;
- Le calcul des captures des espèces de thonidés mineurs par année, mois, engin et espèce ainsi que le calcul de l'effort de pêche unitaire en nombre de jours de pêche en multipliant chaque sortie par la durée moyenne de la marée pour chaque segment de pêche ;
- Le recoupement des données de captures totales par espèce (Tache 2) avec les statistiques Tâche I ;
- La rédaction des rapports régionaux et l'élaboration du rapport national.



Carte 1 : Principaux ports et sites de débarquement des thonidés mineurs au niveau de la façade atlantique marocaine.

3. Description détaillée des jeux de données fournis

Les **tableaux 1 et 2** décrivent les jeux définitifs de données récupérées au niveau des administrations des pêches marocaines (Délégations régionales de Office National des pêche « ONP » et Délégations régionales des Pêches Maritimes « DPM »).

4. Description détaillée des critères de traitement, de contrôle de la qualité et de validation appliqués aux jeux de données

4.1 Traitement de données

Après la récupération des données statistiques des thonidés mineurs exploités par la pêche côtière et artisanale, il a été procédé comme suit :

- La standardisation des formats des bases de données récupérées avant de procéder aux traitements (les formats diffèrent selon les années et les régions) ;
- La standardisation des matricules et des noms des unités de pêche ainsi que leur segment en se basant sur les fichiers armements issu du Département des Pêches Maritimes ;
- La standardisation des noms des espèces de thonidés mineurs (exemple : la bonite est citée sous différents appellations : la bonite à dos rayé, la bonite, la bonite sarda ou sarda sarda) ;
- L'insertion de la variable « Engin de pêche » dans la base de données en fonction des résultats des enquêtes. En effet, le segment, la période de pêche et les espèces débarquées sont les principaux critères utilisés pour affecter l'engin de pêche pour une marrée donnée ;
- Le calcul des captures de chaque espèce des thonidés mineurs par année, mois et engin de pêche. De même, l'effort de pêche a été calculé en nombre de sorties et converti en nombre de jours de pêche en fonction de la durée moyenne des marées par région et par segment de pêche ;

Dans le cas de la pêche aux madragues, les données de capture et d'effort saisies ont été vérifiées enregistrement par enregistrement pour voir leur conformité avec les valeurs enregistrées sur les fiches statistiques.

4.2 Contrôle de la qualité des données

La qualité de la base de données de capture a été graphiquement contrôlée afin de visualiser leur distribution. En effet, une projection des données a été réalisée pour permettre en un seul coup d'œil d'en saisir la tendance générale et de détecter facilement les valeurs aberrantes. Les valeurs qui présentent une déviation par rapport au nuage de points ont été vérifiées dans la base de données pour s'assurer qu'elles sont correctes (**Figures 1, 2, 3.1, 3.2, 4.1, 4.2, 5.1, et 5.2**).

Dans le cas de la pêche aux madragues, la valeur la plus élevée de capture observée sur les **Figures 1 et 2** (enregistrement 132 et 13), respectivement, ne dénote pas une erreur, mais c'est le niveau record de la capture de l'Auxide (*Auxis thazard*) (492 T) réalisée par la madrague de la Méditerranée (madrague 10) en 1998.

Une autre méthode statistique de contrôle de la qualité des données de capture des madragues consistait à la présentation graphique du poids individuel moyen de chacune des trois espèces de thonidés mineurs, calculé comme étant le rapport entre la capture en poids et la capture en nombre. En effet, le poids individuel moyen de l'Auxide (*Auxis thazard*) varie entre 0.3 et 1.25 kg. Pour la Bacorette (*Euthynnus Alleteratus*), le poids individuel moyen varie entre 0.92 et 4.93 kg, alors que celui de la bonite à dos rayé oscille entre 0.4 et 3.6 kg (**Figure 6**). Ces valeurs sont conformes aux informations disponibles dans le manuel ICCAT pour ces espèces. (ICCAT, 2013).

Les **Figures 7.1, 7.2, 7.3, et 7.4** présentent la variation des captures des thonidés mineurs pêchées par les différents types d'unités artisanales et côtières au niveau des différentes régions étudiées. En effet, les barques (TJB < 2 tx) montrent une grande variation de capture ce qui est tout à fait logique vu que ces unités utilisent une variété d'engins et débarquent des captures qui varient de quelques kilogrammes à une centaine de kilogrammes de thonidés mineurs.

Les statistiques descriptives des données de captures (en poids) par segment et par région, ou par espèce et zone, sont résumées dans les **Tableaux 3.1, 3.2, 3.3, 3.4 et 3.5.** Les valeurs élevées de coefficient de variation indiquent une variabilité de la capture de ces espèces entre les unités de pêches côtières et artisanales d'une part et les madragues d'autre part, voir même une variation interannuelle au sein du même segment. Ce phénomène s'explique par le fait que le niveau de capture de ces espèces migratrices est dicté par les facteurs environnementaux qui régissent la disponibilité et l'accessibilité de ces ressources.

4.3 Validation des données

Des critères ont été utilisés pour la validation des données Tâche II récupérées, à savoir :

a) La vérification du taux de couverture de ces données : Dans le cas de la pêcherie des madragues et en termes d'effort de pêche, les données récupérées dans le cadre de cette étude couvrent entre 25 et 100% de l'effort global des madragues au cours de la période 1984-2011 (**Tableau 4**). Elles sont donc statistiquement représentatives de la pêcherie. Dans le cas de la pêcherie côtière et artisanale, les données récupérées couvrent 100% de l'effort global en terme de sorties positives, pour la période 1995-2011 pour les régions étudiées ;

b) La conformité des données récupérées (Tache 2) aux statistiques Tâche I en fonction des captures des espèces : un recoupement des données de captures totales par espèce avec les statistiques Tâche I a été effectué (**Tableaux 5.1, 5.2, 6.1, 6.2, 7.1, 7.2, 8.1 et 8.2**). L'analyse comparative montre que :

   - Pour la période 1986-1994, les données historiques récupérées des madragues sont globalement comparables avec les statistiques Tâche I, avec un rapport de captures totales égale ou inférieur à 1 (**Tableau 8**) ;
   - Les différences observées au niveau des prises totales (**Tableaux 6.1 et 6.2**) sont dues au fait que les données historiques récupérées proviennent d'une seule source officielle (Délégations régionales des Pêches maritimes ou les délégations régionales de l'office national des pêche), tandis que les statistiques Tâche I, élaborées par le Département de la Pêche Maritime (DPM), sont plus complètes. En effet, ce dernier procède à des recoupements en aval avec les statistiques commerciales obtenues auprès de l'Office National de Change ;
   - Les différences entre les données de capture Tâche II et les données de capture Tâche I sont très significatives pour la période 2005- 2011 concernant la pêche côtière et artisanale, et pour la période 1998-2011 en ce qui concerne la pêche aux madragues. En effet, la plupart des données de prises indiquées en jaune dans les **tableaux 7.1, 7.2, 8.1 et 8.**2 ne figurent pas actuellement dans la base de données ICCAT. Ces données concernent notamment le Bonito (BLT), la bonite à dos rayé (BON) et la Bacorette (LTA) de la Méditerranée, d'une part et la Bacorette, la palomette et la bonite à dos rayé de l'Atlantique, d'autre part.

c) La conformité des données de captures récupérées (Tache 2) aux statistiques Tâche I en fonction des engins de pêche : un recoupement des données de captures totales par espèce, par engin et par année avec les statistiques Tâche I a été effectué (**Tableau 9**). Il ressort de cette comparaison une différence dans la répartition des captures par engin de pêche pour la période comprise entre 1984 et 2011. Il est à noter que cette comparaison n'a pu être faite que pour la période 1995-2011 car les données antérieures relatives à la tache II ne sont disponibles que pour les madragues (Site web ICCAT).

5. Jeux de données dans les formats spécifiés de l'ICCAT

Les fichiers associés à ce rapport représentent les statistiques de prise et de l'effort des thonidés mineurs au cours de la période 1995-2011, collectées au niveau de 9 principaux ports/sites de débarquement des thonidés mineurs en Atlantique marocain, ainsi que les données de capture et de l'effort de 12 madragues marocaines pour la période 1986-2011.

Ces données ont été saisies dans les formulaires Tâche 2, pour être intégrées directement dans la base de données ICCAT.

6. Conclusion

La récupération et l'analyse des séries historiques de données tache II des thonidés mineurs exploites au Maroc a été réalisée comme convenu dans le contrat à court terme, conclu entre l'INRH et l'ICCAT dans le cadre du programme de recherche sur les thonidés mineurs (plan de récupération de données), en mai 2013.
La qualité des données de capture et d'effort historiques récupérées (Tache II), statistiquement vérifiée, s'avère satisfaisante.

Par ailleurs, il est à noter que l'analyse de jeux de données Tache I et Tache 11 a montré une légère différence pour certaines années. A cet effet, une révision partielle des statistiques Tâche I est souhaitable.

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Site web : http://iccat.int/

Tableau 1. Description des séries de données historiques de capture et d'effort des unités de pêche côtière et artisanales marocaines, récupérées et saisie dans le formulaire Tâche II de l'ICCAT.

Région	*Port/site*	*Description des jeux de données récupérés*	*Période*	*Taux de réalisation (%)*	*Commentaires*
Dakhla-Labouirda	**Dakhla**	Données journalières par catégorie de Bateaux/Bateau/Espèce[1]	2003 à 2011	100%	-
	Labouirda		2007-2011	100%	-
Laayoune-Tantan	**Laayoune**	Données journalières par catégorie de Bateau/Bateau/espèce	2002-2011	100%	-
		Données mensuelles par catégorie de Bateaux/Bateau/Espèce2	1996, 1997, 1998, 1999 et 2001		-
	Tan-Tan (au lieu de Tarfaya)		1995, 1996,2002, 2008, 2009, 2010 et 2011	100%	Au total 7 années (en conformité avec l'offre soumise)
Moulay Bouselham - Essaouira	**Essaouira**	Données journalières par catégories de Bateaux/Bateau/Espèce	2008 à 2011	100%	-
	El Jadida et Mohammedia		2009 à 2011	50%	Les données journalières relatives aux années 2006 à 2008, ne sont pas inclues dans le rapport, Une fois récupérées, elles seront communiquées au secrétariat de l'ICCAT
		Données mensuelle par espèce[3]	2006-2008	100%	
	Casablanca	Données journalières par catégories de Bateaux/Bateau/Espèce	2007-2011	100%	-
	Mehdia		2004 - 2011	100%	-
Tanger-Larache	**Tanger**	Données des captures et d'effort des madragues disponible sur support papier[4]	1984- 2011	100%	-

[1] Format des données journalières par catégorie de Bateaux/Bateau/Espèce récupérées au niveau des délégations régionales de l'Office National des Pêches :

Port	Date	Matricule	Nom du bateau	Catégorie bateau	Espèce	Poids (kg)	Valeur(Dh)

[2] Format des données mensuelles par catégorie de Bateaux/Bateau/Espèce récupérées au niveau des délégations régionales de l'Office National des Pêches :

Année	Mois	Date	Catégorie bateau	Matricule Bateau	Nom Bateau	TJB	CV	Espèce	Nbre de sorties	Poids(kg)	Valeur(Dh)

[3]Format des données mensuelles par espèce récupérées au niveau des délégations de l'office national des pêches:

Année	Mois	Port	Espèce	Poids (kg)	Valeur(Dh)

[4]Format de saisie des données de captures et d'effort par madrague récupérées au niveau des délégations régionales des pêches maritimes :

Année	Port pêche	Nom madrague	Coordonnées géographiques	Espèce	Capture en poids (kg)	Capture en effectif	Effort (jours calage)

Tableau 2. Description des séries de données historiques de capture et d'effort des madragues marocaines, récupérées et saisie dans le formulaire Tâche II de l'ICCAT.

Année / Madragues	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Madrague 1	*		*	*	*	*	*	*	*		*		*	*	*	*	*	*	*	*	*	*	*	*	*	*		*
Madrague 2						*	*	*	*		*			*	*	*		*	*	*	*	*	*	*	*		*	*
Madrague 3																			*	*	*	*	*		*	*		
Madrague 4							*	*	*		*							*		*	*	*	*	*	*	*	*	*
Madrague 5																				*		*	*	*				
Madrague 6								*			*			*	*	*		*	*	*	*	*	*	*		*		
Madrague 7																					*	*	*	*	*			
Madrague 8																				*	*	*	*	*		*		
Madrague 9																						*	*	*				*
Madrague 10			*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		*	*	*
Madrague 11							*	*	*		*			*	*	*		*	*	*	*	*	*	*				*
Madrague 12																					*	*	*	*			*	

Légende :

* Nouvelles séries historiques récupérées

Capture nulle — Donnée indisponible — Madrague non calée

Tableau 3.1 Statistiques descriptives des données annuelles de captures en poids (kg). Des thonidés mineurs par région et engin, 1995- 2011.

Port	*ENGIN*	*ANNEE*	*MIN*	*Moyenne*	*Max*	*Ecart-type*	*CV*
DAKHLA	GILL, LL	2003	20	1085	5628	1283,18	1,18
DAKHLA	GILL, LL	2004	6	550,8	11130	1257,82	2,28
DAKHLA	GILL, LL	2005	5	840,2	37350	2098,03	2,50
DAKHLA	GILL, LL	2006	3	1279	19180	2663,28	2,08
DAKHLA	GILL, LL	2007	0	949,1	19360	2586,58	2,73
DAKHLA	GILL, LL	2008	4	658,7	12740	1022,50	1,55
DAKHLA	GILL, LL	2009	4	810,1	8096	1028,90	1,27
DAKHLA	GILL, LL	2010	0	1055	17240	1826,20	1,73
DAKHLA	GILL, LL	2011	0	1520	18400	2304,83	1,52
LAAYOUNE	BB, GILL, LL	1996	40	931,4	5320	1158,13	1,24
LAAYOUNE	BB, GILL, LL	1997	40	553,8	2440	482,03	0,87
LAAYOUNE	BB, GILL, LL	1998	32	602,3	3568	531,45	0,88
LAAYOUNE	BB, GILL, LL	1999	40	581,6	4420	629,35	1,08
LAAYOUNE	BB, GILL, LL	2001	16	679,3	4560	630,86	0,93
LAAYOUNE	TRAW	2002	16	436	1920	681,50	1,56
LAAYOUNE	BB, GILL, LL	2002	5	879,5	6400	780,46	0,89
LAAYOUNE	TRAW	2003	48	409,1	928	280,52	0,69
LAAYOUNE	BB, GILL, LL	2003	2	563,1	5872	693,42	1,23
LAAYOUNE	PS	2003	180	184	196	6,93	0,04
LAAYOUNE	TRAW	2004	16	1512	9696	3106,85	2,05
LAAYOUNE	BB, GILL, LL	2004	3	572,1	15460	1017,20	1,78
LAAYOUNE	TRAW	2005	16	68,67	110	39,20	0,57
LAAYOUNE	BB, GILL, LL	2005	1	504	8000	768,92	1,53
LAAYOUNE	TRAW	2006	16	64	112	48,00	0,75
LAAYOUNE	BB, GILL, LL	2006	3	391,3	14000	785,58	2,01
LAAYOUNE	TRAW	2007	8	868,5	15170	2348,84	2,70
LAAYOUNE	BB, GILL, LL	2007	2	388,4	13120	666,44	1,72
LAAYOUNE	TRAW	2008	6	77,94	200	83,96	1,08
LAAYOUNE	BB, GILL, LL	2008	4	442,7	10110	757,81	1,71
LAAYOUNE	TRAW	2009	16	138,3	740	212,89	1,54
LAAYOUNE	BB, GILL, LL	2009	7	378,1	5340	401,21	1,06
LAAYOUNE	TRAW	2010	12	42,86	290	45,66	1,07
LAAYOUNE	BB, GILL, LL	2010	3	355,8	4600	357,01	1,00
LAAYOUNE	TRAW	2011	2	214,4	3360	539,43	2,52
LAAYOUNE	BB, GILL, LL	2011	2	458,7	16000	821,16	1,79
LAAYOUNE	PS	2011	51	52	53	0,82	0,02

LABOUIRDA	GILL	2007	3	107	360	67,30	0,63
LABOUIRDA	GILL	2009	1	40,12	352	47,80	1,19
LABOUIRDA	GILL	2010	3	150,9	750	154,42	1,02
LABOUIRDA	GILL	2011	6	166,4	620	118,46	0,71
Région Casablanca	GILL, TROL	2004	20	87,48	390	75,33	0,86
Région Casablanca	GILL	2004	20	96,65	210	79,61	0,82
Région Casablanca	GILL	2006	30	150	240	30,00	0,20
Région Casablanca	GILL, TROL	2007	9	81,43	112	36,59	0,45
Région Casablanca	GILL	2007	5	65	100	5,00	0,08
Région Casablanca	GILL, TROL	2008	2	6,333	20	6,18	0,98
Région Casablanca	GILL	2009	8	119,5	525	117,78	0,99
Région Casablanca	PS	2009	10	196,7	500	216,38	1,10
Région Casablanca	GILL, TROL	2010	1	65,46	1330	142,22	2,17
Région Casablanca	GILL	2010	4	119,8	420	120,72	1,01
Région Casablanca	PS	2010	15	1871	10080	2313,12	1,24
Région Casablanca	GILL, TROL	2011	1,5	103,2	1000	119,20	1,16
Région Casablanca	GILL	2011	8	132,6	1275	214,55	1,62
Région Casablanca	PS	2011	120	2312	12000	3172,89	1,37
TANTAN	GILL, LL, TN	1995	8	283,6	1236	371,57	1,31
TANTAN	TRAW	1996	4	675,7	11260	1148,01	1,70
TANTAN	GILL, LL, TN	1996	8	673,6	4000	872,42	1,30
TANTAN	GILL, LL, TN	2002	10	1293	11600	1631,20	1,26
TANTAN	GILL, LL, TN	2008	2	138	2540	324,58	2,35
TANTAN	TRAW	2009	13	423,7	1800	690,69	1,63
TANTAN	GILL, LL, TN	2009	2	857,1	9240	1475,78	1,72
TANTAN	GILL, LL, TN	2010	0	1266	19560	1118,73	0,88
TANTAN	GILL, LL, TN	2011	0,13	766,7	7220	2266,08	2,96

Tableau 3.2. Statistiques descriptives des données annuelles de captures en poids (kg) de l'Auxide par les madragues atlantiques entre 1984 et 2011.

Année	***Min***	***Max***	***Moyenne***	***Écart type***	***CV***
1984	554	554	554	na	na
1986	9597	9597	9597	na	na
1987	10745	10745	10745	na	na
1988	2930	2930	2930	na	na
1989	29788	83275	56532	37821	0.67
1990	15667	113098	59475	49096	0.83
1991	0	117661	69388	53033	0.76
1992	0	41368	22736	17097	0.75
1994	0	18939	11613	8915	0.77
1996	0	0	0	na	na
1997	210	20975	7936	9540	1.20
1998	1947	66468	22492	30454	1.35
1999	0	590	162	287	1.77
2000	1125	1125	1125	na	na
2001	0	5087	1934	1983	1.03
2002	0	3700	1395	1686	1.21
2003	0	1355	464	484	1.04
2004	245	8105	3592	2427	0.68
2005	0	9058	1706	2587	1.52
2006	0	10581	1730	3156	1.82
2007	0	4944	2060	2189	1.06
2008	0	1185	174	401	2.30
2009	0	3344	545	983	1.80
2010	0	252	72	115	1.61
2011	0	15968	4074	6467	1.59

Tableau 3.3. Statistiques descriptives des données annuelles de capture en poids (kg) de la Bacorette par les madragues atlantiques entre 1984 et 2011.

Année	*Min*	*Max*	*Moyenne*	*Écart type*	*CV*
1984	0	0	0	na	na
1986	136	136	136	na	na
1987	4840	4840	4840	na	na
1988	984	984	984	na	na
1989	745	1500	1123	534	0.48
1990	3388	30077	13141	12009	0.91
1991	0	0	0	0	na
1992	0	0	0	0	na
1994	0	0	0	0	na
1996	0	0	0	na	na
1997	0	66	17	33	2.0
1998	0	2573	643	1287	2.0
1999	371	7119	3554	3266	0.92
2000	12183	12183	12183	na	na
2001	0	2070	928	938	1.01
2002	0	0	0	0	na
2003	0	460	87	166	1.90
2004	0	15776	3985	5091	1.28
2005	0	145430	14474	43470	3.00
2006	0	3426	785	998	1.27
2007	0	9651	1286	2890	2.25
2008	0	3241	584	992	1.70
2009	0	260	41	96	2.33
2010	0	2980	983	1237	1.26
2011	0	24386	3634	8441	2.32

Tableau 3.4. Statistiques descriptives des données annuelles de capture en poids (kg) de la Bonite à dos rayé par les madragues atlantiques entre 1984 et 2011.

Année	*Min*	*Max*	*Moyenne*	*Écart type*	*CV*
1984	180	180	180	na	na
1986	5359	5359	5359	na	na
1987	17859	17859	17859	na	na
1988	1971	1971	1971	na	na
1989	0	3368	1684	2382	1.41
1990	446	3126	1908	1387	0.73
1991	0	1105	291	471	1.62
1992	0	688	270	314	1.16
1994	0	1460	748	721	0.96
1996	0	0	0	na	na
1997	0	2256	1166	1013	0.87
1998	0	245	61	123	2.00
1999	0	5350	1821	2436	1.34
2000	0	0	0	na	na
2001	0	825	325	344	1.06
2002	0	0	0	0	na
2003	0	1010	126	357	2.83
2004	0	1100	156	368	2.36
2005	0	1965	334	674	2.02
2006	0	268	24	81	3.32
2007	0	558	78	183	2.34
2008	0	0	0	0	na
2009	0	120	10	35	3.46
2010	0	160	23	60	2.65
2011	0	5000	625	1768	2.83

Tableau 3.5. Statistiques descriptives des données annuelles de capture (poids, kg) des thonidés mineurs par la madrague de la Méditerranée entre 1986 et 2007.

Espèce	*Min*	*Max*	*Moyenne*	*Écartype*	*CV*
Auxide (FRI)	0	492108	103456	123892	1.20
Bacorette(LTA)	0	84368	10402	24025	2.31
Bonite à dos rayé(BON)	0	10088	2206	2671	1.21

Tableau 4. Pourcentage des madragues étudiées par année et par zone.

	Atlantique			*Méditerranée*		
Année	***Nbr Madragues étudiées***	***Nbr total madragues***	***%***	***Nbr Madragues étudiées***	***Nbr total madragues***	***%***
1986	1	4	25%	1	1	100%
1987	1	4	25%	1	1	100%
1988	1	4	25%	1	1	100%
1989	2	4	50%	1	1	100%
1990	4	4	100%	1	1	100%
1991	5	5	100%	1	2	50%
1992	4	4	100%	1	1	100%
1994	5	5	100%	1	2	50%
1996	1	3	33%	1	1	100%
1997	4	4	100%	1	1	100%
1998	4	4	100%	1	1	100%
1999	4	4	100%	1	1	100%
2000	1	4	25%	1	1	100%
2001	5	5	100%	1	1	100%
2002	5	6	83%	1	1	100%
2003	8	10	80%	1	1	100%
2004	9	10	90%	1	1	100%
2005	11	12	92%	1	1	100%
2006	11	13	85%	1	1	100%
2007	11	14	79%	1	1	100%
2008	11	15	73%			
2009	12	15	80%			
2010	7	9	78%			
2011	8	10	80%			

Tableau 5.1 Statistiques de captures totales en poids (tonnes) des thonidés mineurs par la pêche côtière et artisanale en Atlantique, provenant des données Tâche II récupérées (Période 1995-2011).

Année	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
BON	12	122	8	55	62	0	84	329	191	517	848	1077	645	1371	2376	2784	4990
BOP	14	37	14	62	52	0	117	75	165	274	277	779	527	256	138	218	258
FRI	0	0	27	71	46	0	72	37	32	0	0	0	50	49	16	9	42
LTA	0	0	7	20	9	0	41	136	61	4	9	16	3	8	10	4	10
TOTAL	26	159	56	208	169	0	314	577	450	795	1135	1872	1225	1684	2540	3015	5300

Tableau 5.2. Statistiques de captures totales en poids (tonnes), par zone de pêche, des thonidés mineurs par les madragues, provenant des données Tâche II récupérées, (Période 1986-2011).

Espèce	***Zone***	***1986***	***1987***	***1988***	***1989***	***1990***	***1991***	***1992***	***1993***	***1994***	***1995***	***1996***	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***
BLT	**MED**	25	27	0	70	204	50	250	53	20		30	6	492	273	205	24	181	83	116	15	0	49	0	0	0	0
BON	**ATL**	5	18	2	3	8	1	1		4		0	5	0	7	0	2	0	1	1	4	0	1	0	0	0	5
BON	**MED**	4	5	1	0	0	0	0	1	1		0	0	2	10	3	5	1	5	4	4	0	1	0	0	0	0
FRI	**ATL**	10	11	3	113	238	347	91		58		0	32	90	1	1	10	7	4	32	19	19	23	2	7	1	33
LTA	**ATL**	0	5	1	2	53	0	0		0		0	0	3	14	12	5	0	1	36	159	9	14	6	0	7	29
LTA	**MED**	0	0	0	0	0	0	0		0		0	0	48	65	84	1	1	7	8	2	0	2	0	0	0	0

Tableau 6.1. Statistiques de captures totales en poids (tonnes) des thonidés mineurs par la pêche côtière et artisanale en atlantique, provenant des statistiques Tâche I (Période 1995-2011).

Année	***1995***	***1996***	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***
BON	699	894	1259	1557	1390	2163	1700	2019	928	989	1411	1655	1053	1419	2523	109	145
BOP	524	2003	246	28	626	1048	830	780	706	503	132		634	391	273	199	213
FRI	645	543	2614	2137	494	582	418	441	184	542	61	48	135	179	9	19	862
LTA	230	588	195	189	67	101	87	308	76	91	33		40	2	63	5	57
TOTAL	2098	4028	4314	3911	2577	3894	3035	3548	1894	2125	1637	1703	1862	1991	2868	403	1277

Tableau 6.2. Statistiques Tâche I de capture s totales en poids (tonnes) des thonidés mineurs par les madragues (Période 1986-2011).

Espèce	ZONE	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
BLT	**MED**	25	27	0	70	394	421	487	123	194	55	0	7	478	210	227	24	0	0	0	0	0	0	0	0	0	0
BON	**ATL**	5	18	2	3	12	0	2	2	4	14	4	5		15	26	6	2	1	6	163	9	114	7	6	9	29
BON	**MED**	4	5	1	0	2	2	0	2	11	0	0	4	2	65	115	5	0	0	0	0	0	0	0	0	0	0
FRI	**ATL**	10	11	3	113	360	408	121	120	71	157	20	55	87	0	0	10	188	4	147	19	18	71	2	0	2	33
LTA	**ATL**	0	5	1	3	78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LTA	**MED**	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Tableau 7.1. Rapport de captures totales (en poids) entre Tâche II (Données récupérées de la pêche côtière et artisanale en Atlantique) et Tâche I, par espèce et par année).

	Année	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
RAPPORT	**BON**	0,02	0,14	0,01	0,04	0,04	0,00	0,05	0,16	0,21	0,52	0,60	0,65	0,61	0,97	0,94	25,54	34,42
	BOP	0,03	0,02	0,06	2,22	0,08	0,00	0,14	0,10	0,23	0,54	2,10	#DIV/0!	0,83	0,65	0,50	1,09	1,21
	FRI	0,00	0,00	0,01	0,03	0,09	0,00	0,17	0,08	0,17	0,00	0,00	0,00	0,37	0,27	1,76	0,45	0,05
	LTA	0,00	0,00	0,04	0,10	0,13	0,00	0,47	0,44	0,81	0,04	0,27	#DIV/0!	0,08	3,94	0,16	0,88	0,17
	TOTAL	0,01	0,04	0,01	0,05	0,07	0,00	0,10	0,16	0,24	0,37	0,69	1,10	0,66	0,85	0,89	7,48	4,15

Tableau 7.2. Rapport de captures totales (en poids) par espèce et par zone entre Tâche II (Données récupérées de la pêche aux madragues) et Tâche I.

Espèce	*Zone*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
BLT	MED	1,00	1,00		1,00	0,52	0,12	0,51	0,43	0,10		#DIV/0!	0,86	1,03	1,30	0,90	1,02	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		#DIV/0!				
BON	ATL	1,07	0,99	0,99	1,12	0,64	#DIV/0!	0,54		0,94		0,00	0,93	#DIV/0!	0,49	0,00	0,27	0,00	1,01	0,23	0,02	0,03	0,01	0,00	0,02	0,02	0,17
BON	MED	1,04	1,00	0,51		0,00	0,00		0,26	0,06			0,08	0,88	0,16	0,03	0,98	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!				
FRI	ATL	0,96	0,98	0,98	1,00	0,66	0,85	0,75		0,82		0,00	0,58	1,03	#DIV/0!	#DIV/0!	0,97	0,04	0,93	0,22	0,99	1,06	0,32	0,96	#DIV/0!	0,25	0,99
LTA	ATL	#DIV/0!	0,97	0,98	0,75	0,67							#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
LTA	MED					0,00								#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		#DIV/0!				

Tableau 8.1. Différences de capture entre Tâche II et Tâche I en tonnes (Pêche côtière et artisanale en Atlantique).

Année	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
BON	-687	-772	-1251	-1502	-1328	-2163	-1616	-1690	-737	-472	-563	-578	-408	-48	-147	2675	4845
BOP	-510	-1966	-232	34	-574	-1048	-713	-705	-541	-229	145	779	-107	-135	-135	19	45
FRI	-645	-543	-2587	-2066	-448	-582	-346	-404	-152	-542	-61	-48	-85	-130	7	-10	-820
LTA	-230	-588	-188	-169	-58	-101	-46	-172	-15	-87	-24	16	-37	6	-53	-1	-47
TOTAL	-2072	-3869	-4258	-3703	-2408	-3894	-2721	-2971	-1444	-1330	-502	169	-637	-307	-328	2612	4023

Tableau 8.2. Différences de capture entre Tâche II et Tâche I en tonnes (Pêche aux madragues).

Espèce	*Zone*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
BLT	MED	0,1	0,0		0,2	-189,6	-371,2	-237,2	-69,6	-173,9		29,8	-1,0	14,1	62,7	-22,4	0,4	181,2	82,8	115,6	14,8		48,8				
BON	ATL	0,4	-0,1	0,0	0,4	-4,4	1,5	-0,9		-0,3		-4,0	-0,3	0,2	-7,7	-26,0	-4,4	-2,0	0,0	-4,6	-159,3	-8,7	-113,1	-7,0	-5,9	-8,8	-24,0
BON	MED	0,2	0,0	-0,5		-2,0	-2,0		-1,5	-10,4			-3,7	-0,2	-54,9	-111,7	-0,1	1,0	5,1	4,4	3,8	0,1	0,8				
FRI	ATL	-0,4	-0,3	-0,1	0,1	-122,1	-61,1	-30,1		-12,9		-20,0	-23,3	3,0	0,6	1,1	-0,3	-181,0	-0,3	-114,7	-0,2	1,0	-48,3	-0,1	6,5	-1,5	-0,4
LTA	ATL	0,1	-0,2	0,0	-0,8	-25,4							0,1	2,6	14,2	12,2	4,6		0,7	35,9	159,2	8,6	14,2	6,4	0,5	6,9	29,1
LTA	MED					-16,0								48,1	65,3	84,4	0,7	1,4	6,8	8,0	1,9		1,9				

Tableau 9. Comparaison entre Tache 1 et Tache 2 par année, espèce et engine.

ANNEE	ESPECES	TACHE 1												TACHE 2											
		BB	GILL	HAND	LL	PS	PSG	SURF	TN	TRAP	TRAW	TROL	UNCL	BB	GILL	HAND	LL	PS	PSG	SURF	TN	TRAP	TRAW	TROL	UNCL
1984	BON	0	0	0	0	30	0	70	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1984	FRI	0	0	0	0	19	0	81	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1984	LTA	0	0	0	0	87	0	13	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1985	BON	0	0	0	0	100	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1985	BOP	0	0	0	0	0	0	100	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1985	FRI	0	0	0	0	0	11	89	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1985	LTA	0	0	0	0	100	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1986	BON	0	0	0	0	98	0	0	0	2	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1986	BOP	0	0	0	0	100	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1986	FRI	0	0	0	0	97	0	0	0	3	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1986	LTA	0	0	0	0	100	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1987	BON	0	0	0	0	0	0	93	0	7	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1987	BOP	0	0	0	0	0	0	100	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1987	FRI	0	0	0	0	0	32	65	0	2	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1987	LTA	0	0	0	0	0	0	95	0	5	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1988	BON	0	0	0	0	0	0	100	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1988	BOP	0	0	0	0	0	0	100	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1988	FRI	0	0	0	0	0	0	98	0	2	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1988	LTA	0	0	0	0	0	0	98	0	2	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1989	BON	0	0	0	0	0	0	99	0	1	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1989	BOP	0	0	0	0	0	0	100	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1989	FRI	0	0	0	0	0	0	81	0	19	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*

1989	**LTA**	0	0	0	0	0	0	79	0	21	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1990	**BON**	0	19	0	0	78	0	0	0	2	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1990	**BOP**	0	1	0	0	99	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1990	**FRI**	0	26	0	0	39	0	0	0	34	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1990	**LTA**	0	0	0	0	79	0	0	0	21	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1991	**BON**	0	8	0	0	92	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1991	**BOP**	0	0	0	0	100	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1991	**FRI**	0	62	0	0	2	0	0	0	36	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1991	**LTA**	0	53	0	0	47	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1992	**BON**	0	12	0	0	88	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1992	**BOP**	0	9	0	0	91	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1992	**FRI**	0	55	0	0	9	0	0	0	36	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1992	**LTA**	0	0	0	0	100	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1993	**BON**	0	6	0	0	94	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1993	**BOP**	0	1	0	0	99	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1993	**FRI**	0	31	0	0	26	0	0	0	44	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1993	**LTA**	0	0	0	0	59	0	0	0	0	0	0	41	*	*	*	*	*	*	*	*	*	*	*	*
1994	**BON**	0	3	0	0	96	0	0	0	1	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1994	**BOP**	0	1	0	0	99	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1994	**FRI**	0	41	0	0	1	0	0	0	58	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1994	**LTA**	0	0	0	0	100	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*
1995	**BON**	0	4	0	0	94	0	0	0	2	0	0	0	0	16	0	0	0	0	0	0	54	30	0	0
1995	**BOP**	0	0	0	0	100	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	80	0	0
1995	**FRI**	0	6	0	0	69	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0
1995	**LTA**	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1996	**BON**	0	3	0	0	96	0	0	0	0	0	0	0	0	47	0	0	0	0	0	0	3	50	0	0
1996	**BOP**	0	1	0	0	99	0	0	0	0	0	0	0	0	76	0	24	0	0	0	0	0	0	0	0
1996	**FRI**	0	19	0	0	77	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0
1996	**LTA**	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	**BON**	0	2	0	0	97	0	0	0	0	0	0	0	0	62	0	0	0	0	0	0	38	0	0	0
1997	**BOP**	0	13	0	0	87	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
1997	**FRI**	0	0	0	0	98	0	0	0	2	0	0	0	0	33	0	0	0	0	0	0	67	0	0	0
1997	**LTA**	0	1	0	0	99	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
1998	**BON**	0	5	0	0	95	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
1998	**BOP**	0	0	0	0	100	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
1998	**FRI**	0	24	0	0	72	0	0	0	4	0	0	0	0	45	0	0	0	0	0	0	55	0	0	0
1998	**LTA**	0	0	0	0	100	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
1999	**BON**	0	3	0	0	96	0	0	0	1	0	0	0	0	80	0	0	0	0	0	0	20	0	0	0
1999	**BOP**	0	5	0	0	95	0	0	0	0	0	0	0	0	99	0	1	0	0	0	0	0	0	0	0
1999	**FRI**	0	15	0	0	85	0	0	0	0	0	0	0	0	99	0	1	0	0	0	0	0	0	0	0
1999	**LTA**	0	0	0	0	100	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
2000	**BON**	0	7	0	0	92	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0
2000	**BOP**	0	5	0	0	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	**FRI**	0	15	0	0	85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	**LTA**	0	12	0	0	88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	**BON**	0	5	0	0	95	0	0	0	0	0	0	0	0	93	0	0	0	0	0	0	7	0	0	0
2001	**BOP**	0	2	0	0	98	0	0	0	0	0	0	0	0	98	0	2	0	0	0	0	0	0	0	0
2001	**FRI**	0	6	0	0	91	0	0	0	2	0	0	0	0	88	0	0	0	0	0	0	12	0	0	0
2001	**LTA**	0	21	0	0	79	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
2002	**BON**	0	4	0	0	96	0	0	0	0	0	0	0	0	98	0	1	0	0	0	0	1	0	0	0

2002	**BOP**	0	1	0	0	99	0	0	0	0	0	0	0	1	59	0	37	0	0	0	0	0	3	0	0
2002	**FRI**	0	13	0	0	45	0	0	0	43	0	0	0	0	12	0	4	0	0	0	0	84	0	0	0
2002	**LTA**	0	18	0	0	82	0	0	0	0	0	0	0	1	90	0	9	0	0	0	0	0	0	0	0
2003	**BON**	0	7	0	0	93	0	0	0	0	0	0	0	0	99	0	0	0	0	0	0	1	0	0	0
2003	**BOP**	0	0	0	0	100	0	0	0	0	0	0	0	0	55	0	45	0	0	0	0	0	0	0	0
2003	**FRI**	0	21	0	0	77	0	0	0	2	0	0	0	0	64	0	21	0	0	0	0	11	4	0	0
2003	**LTA**	0	8	0	0	92	0	0	0	0	0	0	0	0	92	0	6	0	0	0	0	0	2	0	0
2004	**BON**	0	5	0	0	95	0	0	0	1	0	0	0	0	99	0	0	0	0	0	0	1	0	0	0
2004	**BOP**	0	0	0	40	60	0	0	0	0	0	0	0	0	45	0	54	0	0	0	0	0	1	0	0
2004	**FRI**	0	17	1	19	37	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0
2004	**LTA**	0	1	0	0	99	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
2005	**BON**	0	28	17	38	5	0	0	0	12	0	0	0	0	84	0	0	0	0	0	0	16	0	0	0
2005	**BOP**	0	0	1	10	88	0	0	0	2	0	0	0	0	87	0	13	0	0	0	0	0	0	0	0
2005	**FRI**	0	21	20	16	11	0	0	0	31	0	0	0	0	1	0	0	0	0	0	0	99	0	0	0
2005	**LTA**	0	0	0	0	100	0	0	0	0	0	0	0	0	84	0	16	0	0	0	0	0	0	0	0
2006	**BON**	0	19	14	60	6	0	0	0	1	0	0	0	0	99	0	0	0	0	0	0	1	0	0	0
2006	**BOP**	0	0	0	0	0	0	0	0	0	0	0	0	0	91	0	9	0	0	0	0	0	0	0	0
2006	**FRI**	0	8	23	17	15	0	0	0	38	0	0	0	0	1	0	0	0	0	0	0	99	0	0	0
2006	**LTA**	0	0	0	0	0	0	0	0	0	0	0	0	0	92	0	2	0	0	0	0	0	0	0	6
2007	**BON**	0	13	17	51	8	0	0	0	11	0	0	0	0	78	0	0	0	0	0	0	15	5	0	2
2007	**BOP**	0	0	0	91	9	0	0	0	0	0	0	0	0	39	0	23	0	0	0	0	0	33	0	5
2007	**FRI**	0	1	7	32	8	0	0	0	53	0	0	0	0	41	0	0	0	0	0	0	59	0	0	0
2007	**LTA**	0	0	0	98	3	0	0	0	0	0	0	0	0	52	0	1	0	0	0	0	0	46	0	0
2008	**BON**	0	14	20	57	8	0	0	0	0	0	0	0	0	99	0	0	0	0	0	0	1	0	0	0
2008	**BOP**	0	0	0	91	8	0	0	0	0	0	0	0	0	85	0	15	0	0	0	0	0	0	0	0

2008	**FRI**	0	2	14	59	23	0	0	0	1	0	0	0	0	96	0	0	0	0	0	0	4	0	0	0
2008	**LTA**	0	0	0	100	0	0	0	0	0	0	0	0	0	91	0	9	0	0	0	0	0	0	0	0
2009	**BON**	0	7	19	36	37	0	0	0	0	0	0	0	0	98	0	0	0	0	0	1	0	0	0	0
2009	**BOP**	0	1	0	81	18	0	0	0	0	0	0	0	0	95	0	2	0	0	0	0	0	1	0	1
2009	**FRI**	0	0	22	44	33	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
2009	**LTA**	0	0	0	5	95	0	0	0	0	0	0	0	0	92	0	0	0	0	0	0	0	5	0	3
2010	**BON**	0	1	15	20	56	0	0	0	8	0	0	0	0	99	0	0	0	0	0	0	0	0	0	0
2010	**BOP**	0	2	0	68	30	0	0	0	0	0	0	0	0	83	0	1	14	0	0	0	0	1	0	1
2010	**FRI**	0	0	26	47	16	0	0	0	11	0	0	0	0	68	0	0	13	0	0	0	19	0	0	0
2010	**LTA**	0	0	0	0	100	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
2011	**BON**	0	0	11	61	8	0	0	0	20	0	0	0	0	98	0	0	0	0	0	0	1	0	0	0
2011	**BOP**	0	0	28	54	19	0	0	0	0	0	0	0	0	87	0	2	9	0	0	0	0	2	0	0
2011	**FRI**	0	0	29	32	35	0	0	0	4	0	0	0	0	31	0	0	25	0	0	0	44	0	0	0
2011	**LTA**	0	0	16	49	35	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0

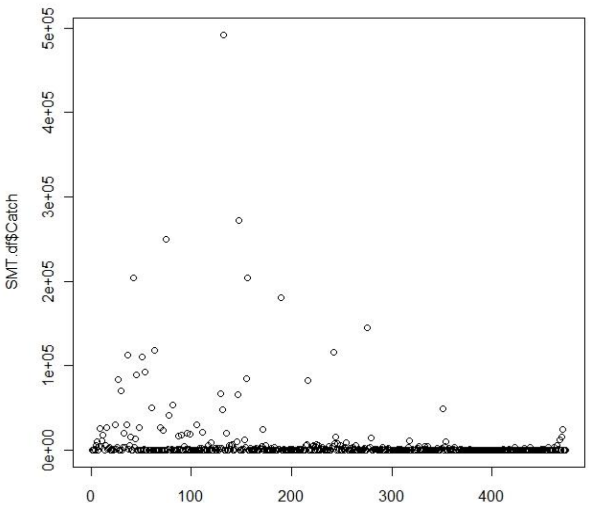

Figure 1. Présentation graphique des captures en poids (kg) des thonidés mineurs capturées par les madragues marocaines entre 1984 et 2011

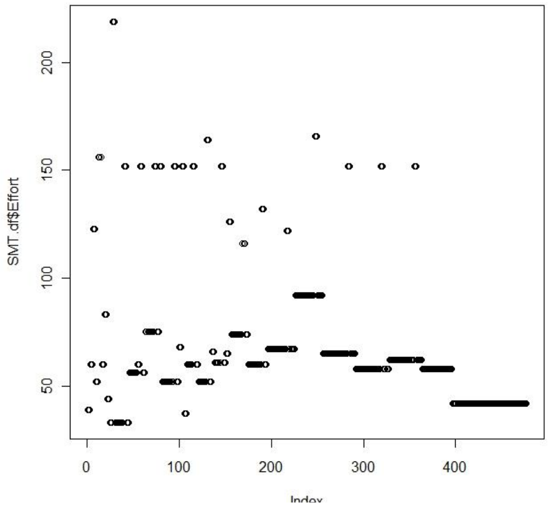

Figure 2. Présentation graphique des données d'effort (nombre jours calage) des madragues marocaines entre 1984 et 2011

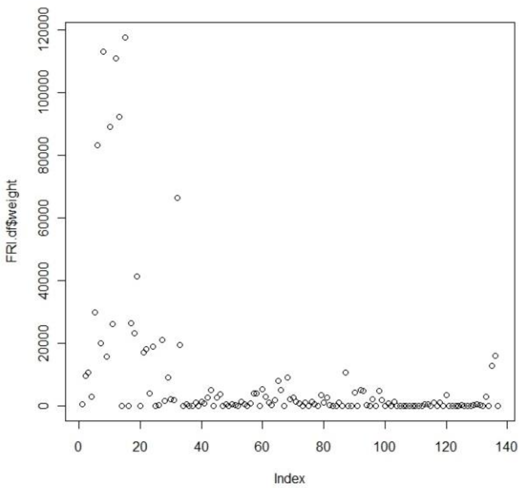

Figure 3.1. Présentation graphique des données de capture en poids (kg) de l'auxide (*Auxis thazard*) capturée par les madragues de l'Atlantique

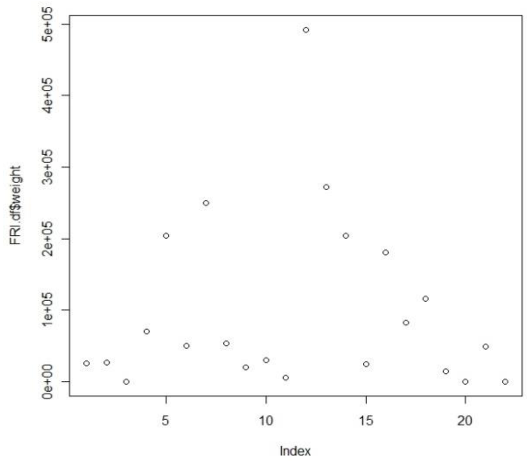

Figure 3.2. Présentation graphique des données de capture en poids (kg) de l'auxide (*Auxis thazard*) capturée par les madragues de la Méditerranée

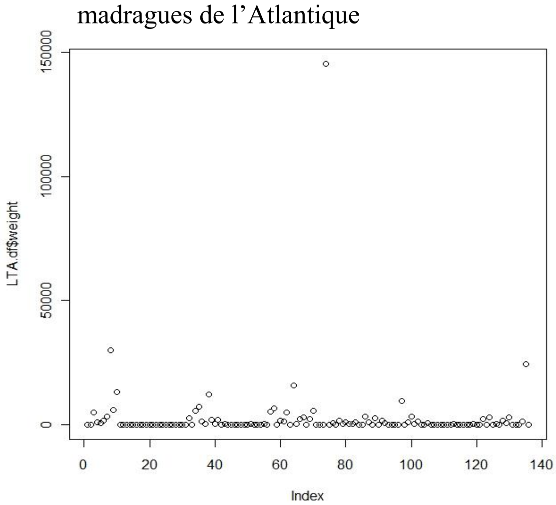

Figure 4.1. Présentation graphique des données de capture en poids (kg) de la bacorette (*Euthynnus alleteratus*) capturée par les madragues de l'Atlantique

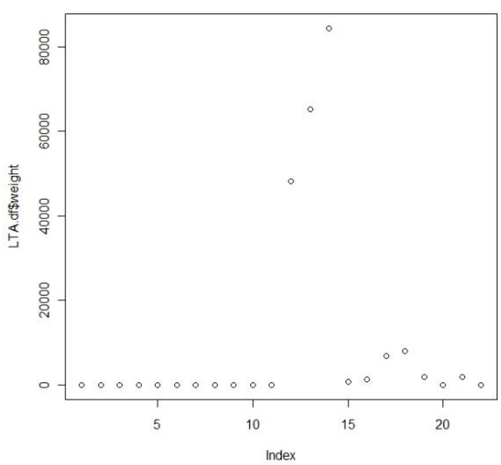

Figure 4.2. Présentation graphique des données de capture en poids (kg) de la bacorette (*Euthynnus alleteratus*) capturée par les madragues de la Méditerranée

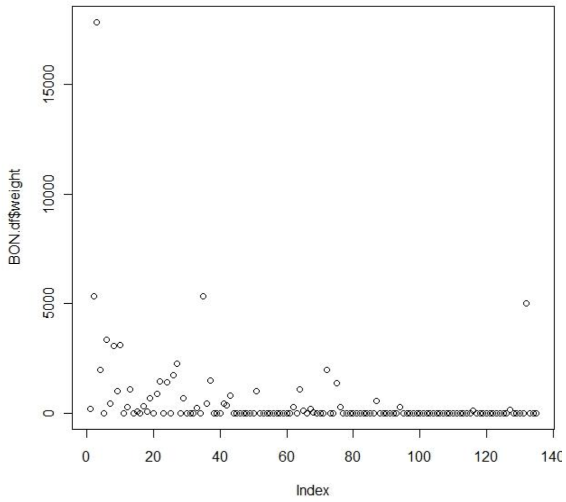

Figure 5.1. Présentation graphique des données de capture en poids (kg) de la bonite (*Sarda sarda*) capturée par les madragues de l'Atlantique

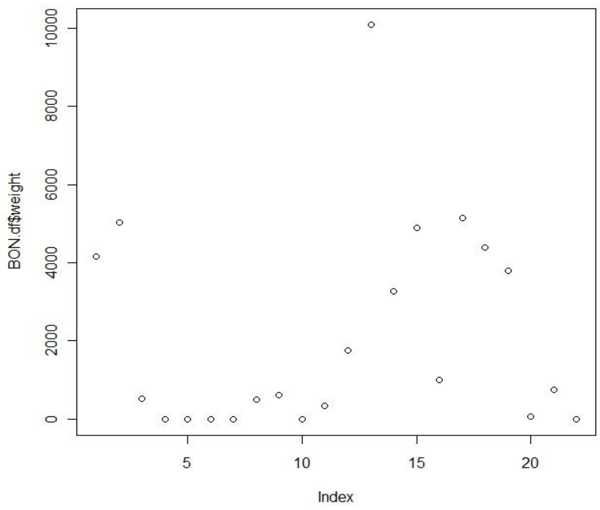

Figure 5.2. Présentation graphique des données de capture en poids (kg) de la bonite (*Sarda sarda*) capturée par les madragues de la Méditerranée

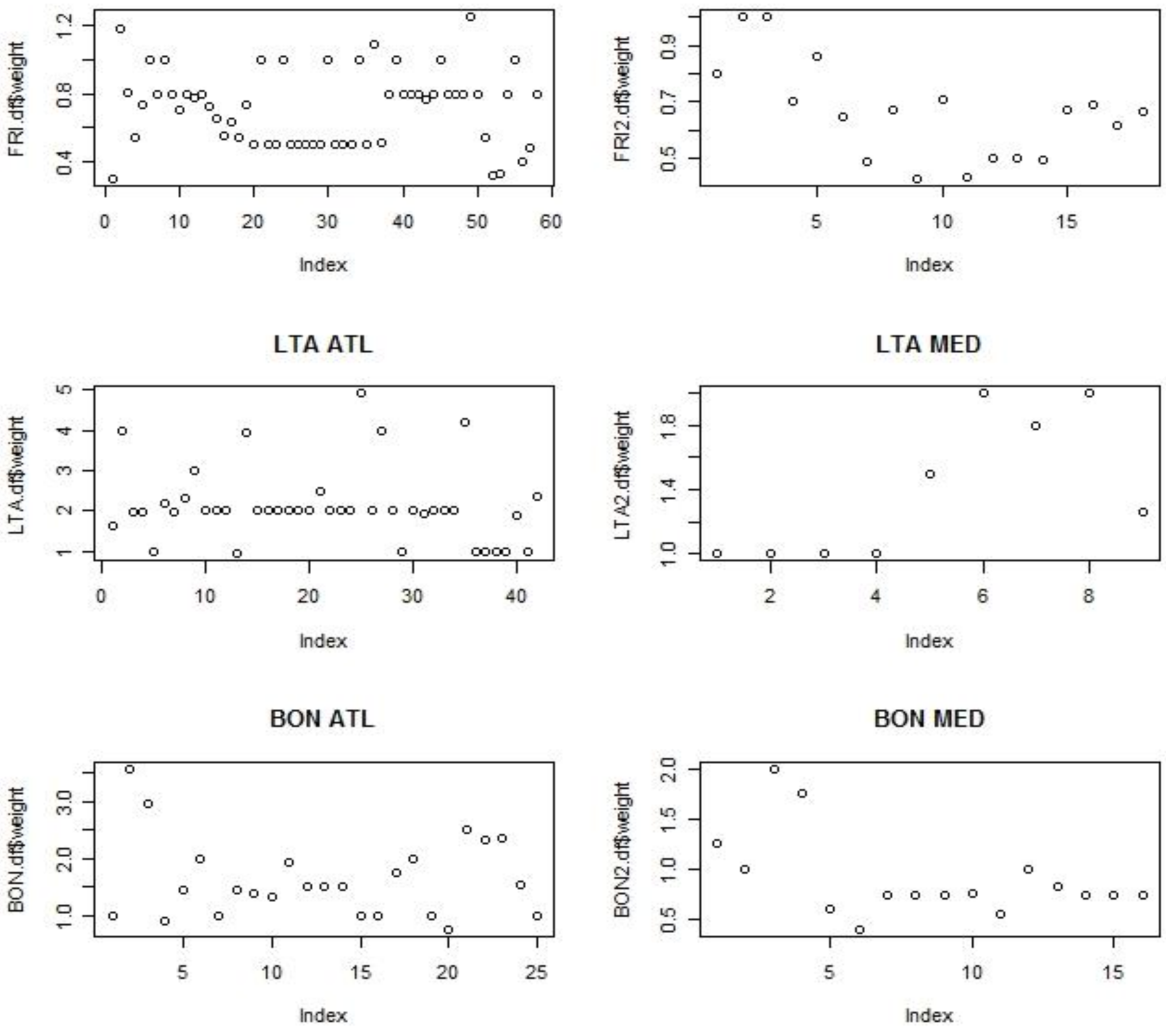

Figure 6. Présentation graphique des données de poids individuel moyen des thonidés Mineurs par espèce et par zone.

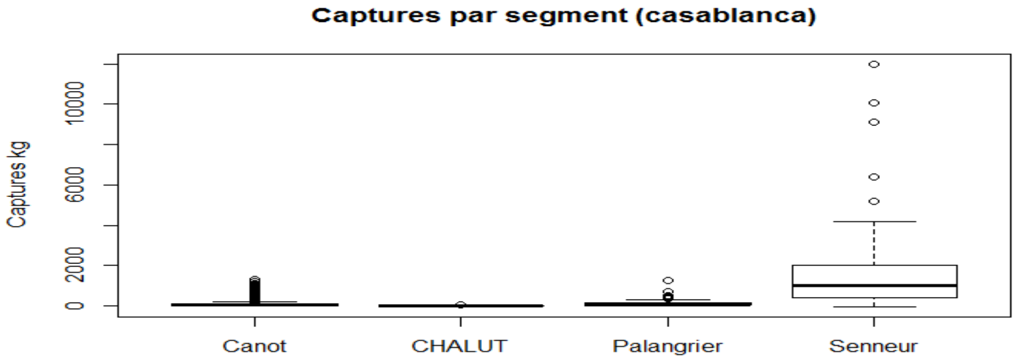

Figure 7.1. Présentation graphique des données des captures des thonidés mineurs par segment de pêche au niveau de la région de Casablanca.

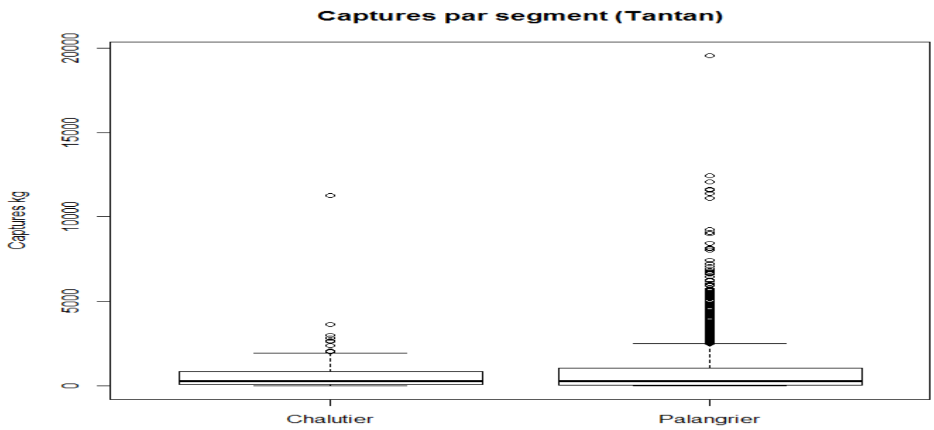

Figure 7.2. Présentation graphique des données des captures des thonidés mineurs par segment de pêche au niveau de la région de Tantan.

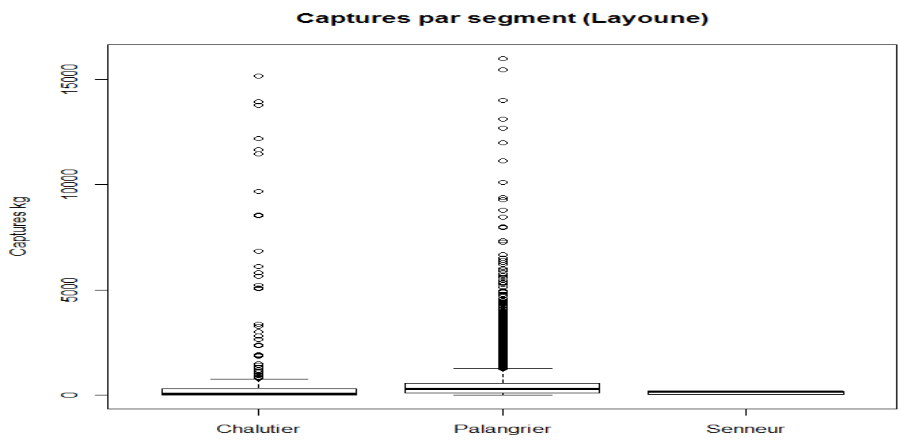

Figure 7.3. Présentation graphique des données des captures des thonidés mineurs par segment de pêche au niveau de la région de Laayoune.

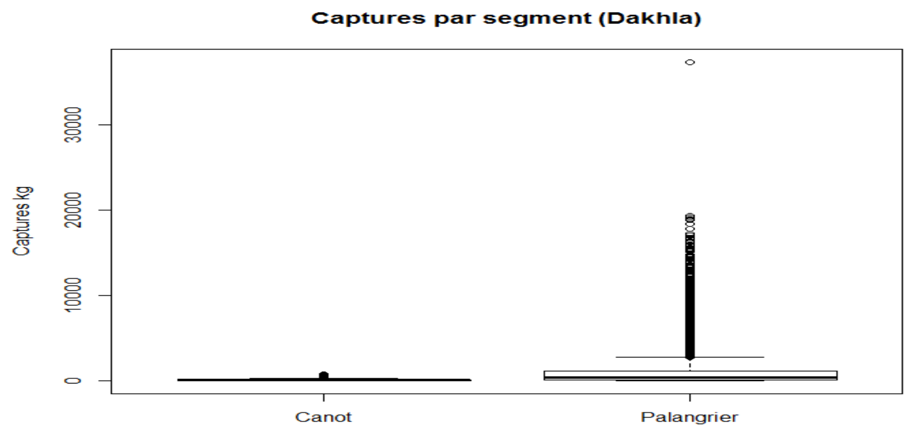

Figure 7.4. Présentation graphique des données des captures des thonidés mineurs par segment de pêche au niveau de la région de Dakhla.

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PROGRAMME DE RECHERCHES SUR LES THONIDES MINEURS

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SUMMARY

This document reflects the work carried out by researchers of the Center for Oceanographic Research of Abidjan within the framework of the ICCAT Year Research Programme for Small Tunas (SMTYP) which was adopted by the SCRS in 2011 and by the Commission in 2012 in Agadir (Morocco). The main objective of this programme is to improve basic statistical and biological data collection related to small tunas (SMT) in order to assess the state of these stocks within ICCAT. The work carried out is mainly in line with the first phase of this research programme whose purpose is to recover the historical small tuna data sets that are currently not included in the ICCAT data base. This has resulted in the production of Task II statistics (catch and effort by species, gear, month and area) and Task II (size and/or weight of samples by species, gear, time strata and area) of ICCAT. The funding granted within the framework of this programme has allowed to 1) mobilize the technical means and human skills required for the recovery of these historical data and 2) develop a data base for the input of artisanal maritime fishery data in Côte d'Ivoire. This document refers to the existing difficulties in the current data collection system and suggests the implementation of a strategy aimed at making the data collection system even more reliable and more complete.

RESUME

Ce document rend compte du travail accompli par des chercheurs du Centre de Recherches Océanologiques d'Abidjan dans le cadre du programme ICCAT de recherche sur les thonidés mineurs (SMT) qui a été adopté par le SCRS en 2011 et par la commission en 2012 à Agadir (Maroc). L'objectif principal de ce programme est d'améliorer la collecte des données statistiques et biologiques de base concernant les SMT en vue d'évaluer l'état futur de ces stocks au sein de l'ICCAT. Le travail effectué s'inscrit en particulier dans la première phase de ce programme de recherche dont la finalité est de récupérer les jeux de données historiques sur les thonidés mineurs, ne figurant pas actuellement dans la base de données de l'ICCAT. Il a abouti à la production des statistiques de la tâche II (captures et efforts par espèce, engin, mois et zone) et la tâche II (Taille et/ou poids des échantillons par espèce, engin, strate temporelle et zone) de l'ICCAT. Le financement octroyé dans le cadre de ce projet a permis (1) de mobiliser les moyens techniques et les compétences humaines nécessaires à la reconstitution de ces données historiques et (2) d'élaborer une base de données pour la saisie des données de la pêche artisanale maritime en Côte d'Ivoire. Ce document fait état des difficultés existantes dans le système de collecte de données actuel et propose une stratégie à mettre en place afin de rendre le système de collecte de données encore plus fiable et plus complet.

RESUMEN

Este documento presenta el trabajo realizado por los investigadores del Centro de investigación oceanográfica de Abiyán en el marco del programa ICCAT de investigación sobre pequeños túnidos (SMT) que fue adoptado por el SCRS en 2011 y por la Comisión en 2012 en Agadir (Marruecos). El objetivo principal de este programa es mejorar la recopilación de datos estadísticos y biológicos básicos relacionados con los pequeños túnidos para evaluar en el futuro el estado de estos stocks en el marco de ICCAT. El trabajo realizado se enmarca en particular en la primera fase de este programa de investigación cuya finalidad es recuperar conjuntos de datos históricos sobre pequeños túnidos que no figuran actualmente en la base de datos de ICCAT. Se ha centrado en la producción de estadísticas de Tarea II (captura y esfuerzo por especie, arte, mes y zona) y Tarea II (talla y/o peso de las muestras por especie, arte, estrato temporal y zona) de ICCAT. La financiación obtenida en el marco de este proyecto ha permitido (1) movilizar los medios técnicos y los recursos humanos necesarios para la reconstitución de estos datos históricos y (2) elaborar una base de datos para introducir estos *datos de la pesca artesanal marítima en Côte d Ivoire. Este documento presenta las dificultades existentes en el sistema de recopilación de datos actual y propone una estrategia para que el sistema de recogida de datos sea aún más fiable y más completo.*

KEYWORDS

Fishery statistics, Data recovery, Artisanal fisheries, Small tunas

1. Contexte général et objectifs

Les thonidés mineurs sont exploités dans le Golfe de Guinée par les bateaux industriels (senneurs et chalutiers) et les embarcations artisanales. Ces deux types d'unités de pêche capturent depuis des années, une grande quantité de thonidés mineurs directement écoulées sur le marché local pour la consommation de la population. Ainsi, des emplois directs et indirects ont été créés dans les pays côtiers et particulièrement en Côte d'Ivoire par la pratique de cette activité. Cependant, cette pêche n'est pas régulièrement suivie par les scientifiques en vue de la planification et de la constitution des bases de données. Les jeux des données historiques relatifs aux captures de ces espèces sont parfois inexistants dans la base de données de la Commission Internationale pour la Conservation des Thonidés de l'Atlantique (**Tableau 1**). Cela constitue un frein à l'élaboration de politiques pour une meilleure gestion de ces stocks pour les pays côtiers. Dans le souci de créer une base de données internationale sur les thonidés mineurs, la plus complète possible, la CICTA a mis en place un programme de récupération de données historiques en Afrique de l'Ouest. La production des statistiques qui inclut la tâche II (captures et efforts par espèce, engin, mois et zone) et la tâche II (Taille et/ou poids des échantillons par espèce, engin, strate temporelle et zone) sont les résultats attendus par l'ICCAT dans le cadre de cette restitution. Le présent rapport a pour objectif principal de faire le bilan du travail effectué à travers la présentation de la méthodologie, des résultats obtenus, des difficultés rencontrées et des perspectives pour une amélioration de la collecte des données.

2. Méthodologie

2.1 Récupération des données

Les données disponibles relatives aux thonidés mineurs proviennent du Centre de Recherches Océanologiques (CRO) et de l'Université Nangui Abrogoua (UNA).

- *Données provenant du CRO*

Les données issues du CRO ont été collectées depuis les années 1990 par les chercheurs du centre dans le cadre de projets divers et/ou de leurs activités de routine.
Les données inventoriées au CRO sont pour la plupart des cas sur support papier. Seules les données récentes étaient disponibles sur support informatique. Les informations disponibles sur support papier concernent la période de 1990 à 2006 pour toutes les espèces. Les données de 2007 à 2011, sont disponibles en partie sur support électronique.

- *Données provenant de l'UNA*

Les données issues de l'UNA sont les informations collectées dans le cadre d'études doctorales portant sur les différentes espèces de thonidés mineurs, réalisées sur l'ensemble du littoral ivoirien. Ces données ont été collectées lors des débarquements des chalutiers au port d'Abidjan. Toutes ces fiches ont été saisies et sont disponibles sur support électronique.

2.2 Inventaire des informations collectées

Les supports de collectes des données ont évolué au fil des années passant de simples carnets de note à des formulaires plus aboutis et structurés. Les informations collectées ont par la suite gagné en volume au fil des années. La précision dans la collecte de données a également augmenté, notamment au niveau de l'identification des espèces et de l'effort de pêche. L'inventaire des informations a donc consisté à répertorier puis confronter l'ensemble des variables occurrentes afin d'en établir la synthèse des informations disponibles.

Cet inventaire a permis de catégoriser les informations selon trois formulaires : (1) *un formulaire de collectes de données de production* qui intègre les données de captures ou de vente ; (2) *un formulaire d'échantillonnage de taille* qui comprend les données de mensurations. Il s'agit généralement des tailles (longueur à la fourche) et quelquefois de poids pour certaines espèces et enfin *un formulaire d'effort de pêche* dénombrant en particulier le nombre de pirogues sorties et/ou entrées.

2.3 Description du système de collecte

Les espèces d'intérêt de la CICTA sont essentiellement pêchées par les senneurs, les pêcheurs artisans au filet maillant dérivant et dans une moindre mesure par les chalutiers. Les données de la pêche artisanale ont fait l'objet d'analyse partielle en fin 1984 et 1985 puis d'un enregistrement continu des captures des principales espèces à partir de 1988. La pêche sportive a, à un moment donné contribué à la production de ces espèces, mais rares sont les données historiques actuellement accessibles. La collecte des données de la pêche maritime en Côte d'Ivoire est effectuée par le l'Institut de Recherche pour le Développement (IRD) et le CRO. Cependant, les données de la pêche industrielle hauturière sont gérées par l'IRD et celles de la pêche artisanale hauturière par le CRO. Relativement à la pêche artisanale hauturière, les premiers suivis ont débuté dès le début des années 1980 par les chercheurs de l'ORSTOM (actuel IRD).

- *Pêche chalutière*

Tous les chalutiers débarquent au port de pêche d'Abidjan entre 22 h et 05 h du matin. Les informations sur les caractéristiques des chalutiers et leurs mouvements d'entrée et de sortie du port sont enregistrés quotidiennement au bureau de la capitainerie où des techniciens supérieurs du CRO se rendent deux fois par semaine pour récupérer les enregistrements. Ces enregistrements sont ensuite utilisés pour calculer l'effort de pêche. Depuis 2006, les fiches de vente ne sont plus fournies bateau par bateau mais de façon globale. Les chalutiers congélateurs ne disposant pas de cahiers de bord, il est souvent difficile de reconstituer toutes les informations surtout lorsqu'il y a des pertes de fiches de vente.

Les chalutiers débarquent toutes leurs prises au port de pêche d'Abidjan. Chaque bateau effectue ensuite sa vente à la criée, en caisses, par groupe d'espèces similaires ou en tas (poissons nobles triés pendant le débarquement par les clients eux-mêmes). Chaque groupe commercial, indiqué par son espèce dominante est vendu en trois catégories : "petit", "moyen" et "gros". Les poissons de qualité supérieure ne sont pas vendus sur le quai mais sont réservés aux supermarchés et/ou aux restaurants. Les ventes à quai sont toutes effectuées en présence d'un agent qui marque les quantités vendues et les prix sur des bordereaux qui sont eux aussi récupérés par des techniciens du CRO pour l'évaluation des quantités débarquées. L'évaluation de la production se fait donc de façon exhaustive.

- *Pêche artisanale (filet maillant dérivant)*

Le schéma de collecte des données est un modèle relativement simple dans lequel les principaux acteurs sont les chercheurs et les techniciens. Ces derniers se basent sur les formulaires édités par les chercheurs pour la collecte des données. Les données sont ensuite saisies par des opératrices de saisie dans des fichiers Excel et remis aux chercheurs responsables des données pour les traitements.

La collecte des données se fait sur les principaux sites de débarquement par les enquêteurs présents tous les jours ouvrables. Les pêcheurs ne disposant pas de documents rapportant leurs activités, il est indispensable d'effectuer des échanges réguliers avec eux pour avoir des informations supplémentaires (ex. zones de pêche) lors des débarquements à quai ou sur les étals. Ainsi, les informations collectées portent sur la taille et le poids des espèces, le nombre de pirogues débarquées et sorties. Les enquêteurs chargés de collecter les différentes données sur les sites de débarquement sont répartis comme suit :

- 05 sur les sites d'Abidjan et environnant

    - 02 au port de pêche d'Abidjan
    - 02 à Abobo-Doumé
    - 01 à Zimbabwe

- 01 enquêteur à San-Pédro
- 01 enquêteur à Sassandra

2.4 Saisie des données (base de données)

Trois tables de saisie ont été créées dans Access pour la saisie de l'ensemble des informations. Il s'agit des tables : **Production**, **Mensuration** et **Effort**. Les champs des différentes tables sont décrits en **Annexe 1**.

2.5 Validation des données

La première étape de la validation des données a consisté à la vérification de l'exhaustivité de la saisie des données récupérées relatives aux thonidés mineurs. Des requêtes de synthèse journalière ont ainsi été effectuées puis confrontées aux synthèses figurant sur les formulaires papiers. Ce premier niveau de vérification a permis de corriger les informations erronées, de saisir des données complémentaires ou de supprimer les doublons dans les saisies préalablement effectuées.

Les formulaires ont évolué au fil des années à cause de la diversité des enquêteurs et surtout de l'absence de document de référence expliquant les termes et les acronymes utilisés par les uns et les autres. La conséquence de ces évolutions a été la multiplicité des thèmes utilisés pour décrire un même sujet. La saisie des données par les différents acteurs a également provoqué l'introduction de termes différents pour signifier la même chose. Nous avons donc procédé à l'uniformisation des informations saisies en établissant pour chaque champ un tableau de correspondance pour la mise à jour du champ concerné. Nous avons par exemple créé un fichier de correspondance des espèces en utilisant le fichier listant les espèces de l'ICCAT, leur classification par groupe, les noms scientifiques et les codes FAO.

Les saisies ont été mises à jour sur la base de ces tableaux de références. Les informations portées sur les formulaires ont souvent permis d'être précis dans la recodification effectuée. Cependant, certaines recodifications ont été maintenu à des niveaux plus agrégés lorsque les informations ne permettent de faire autrement.

2.6 Traitement des données

Le traitement des données a nécessité un certain nombre d'hypothèses de travail.

- *Données supprimées ou ajustées.*

Certaines données ont été supprimées du fait de leur caractère imprécis. En effet, en lieu et place des nombres ou des poids débarqués, il a été marqué des pourcentages (par exemple MAW=10%, FRI=50%) à certains endroits. Ainsi, 101 données ont été supprimées dans la table PRODCUTION du fait de ces valeurs en « pourcentage » qui n'ont pas pu être traduites en informations nominales ou pondérales. De même, 144 lignes d'informations de type qualitatif comme « beaucoup », « peu » ou encore « quelques » sont présentes dans les données. Ces informations ont été interprétées suivant les informations procurées par l'enquêteur qui a collecté ces données. Selon lui, les termes étaient utilisés pour caractériser des situations bien précises. Les quantités n'ont pas été marqués parce qu'il fallait produire des nombres et cela n'était pas toujours évident. Du coup, les enquêteurs mettaient « Beaucoup, Quelques ou Peu » lorsqu'il y avait environ 1000, 200 ou 50 individus, respectivement (Barrigah Siméon, *Com. Pers.*). Des corrections ont ainsi été apportés à la table des PRODUCTION en remplaçant les termes « Beaucoup, Quelques ou Peu » par 1000, 200 ou 50 individus, respectivement.

- *Table de référence espèce.*

Une table de correspondance des espèces a été effectuée afin de traduire les correspondances entre les appellations locales et les appellations conventionnelles utilisées par la CICTA.

Par exemple, l'*Auxide thazard* est noté « auxides » par les enquêteurs. Ces données notent également « Auxides/Thonines ou Thonines/Auxides » lorqu'il s'agit d'un mélange ou en cas de non identification de l'espèce. La table de correspondance établie pour les thonidés mineurs est présentée au **Tableau 1**.

- *Conversion des nombres en poids.*

Le type d'estimation quantitative fournit par les enquêteurs dans les données de production est le nombre. Il a été utilisé des poids moyens des individus de SMT pour le calcul des quantités débarquées en kilogrammes. Pour ce faire, il a été utilisé les données de la table MENSURATION afin de calculer les paramètres a et b de la relation taille poids (W=aL^b). Le calcul de ces paramètres a été possible car les mensurations ont porté à certains moment, à la fois sur la longueur à la fourche et les poids de chaque individus. Les paramètres ont été ensuite appliqués dans les cas où seules les longueurs à la fourche ont été mesurées. Enfin, les poids moyens ont été calculés en considérant à la fois les poids mesurés et calculés. Aucune mensuration d'*Auxide rochei* n'est présente dans les données. Nous avons donc utiliser un poids moyen correspondant à celui de l'*Auxide thazard*.
De même, le poids moyen utilisé pour les FRZ est la moyenne des poids moyen de Eu*thynnus alletterattus* et de *Auxide thazard.* Cf. **Tableau 2** ci-dessous.

- *Calcul des productions totales.*

Logiquement, les espèces mesurées devraient être un échantillon de la production totale. En réalité, les deux informations (MENSURATION et PRODUCTION) sont indépendantes. En effet, les enquêteurs commencent toujours par mesurer systématiquement les poissons débarqués. Ils finissent quelquefois par tout mesurer lorsque les débarquements sont faibles. Mais le plus souvent, les mensurations sont effectuées dans les premiers débarquements. Le nombre d'individus à mesurer n'est pas fixé et les enquêteurs lorsque ces derniers estiment avoir fait beaucoup de mesures ou lorsque les mesures sont impossibles, alors, ils procèdent à un dénombrement des prises par espèces. Ces informations sont ainsi enregistrées dans le formulaire PRODUCTION. La quantité totale débarquée correspond donc à la somme des nombres mentionnés dans le fichier PRODUCTION et des individus mesurés. Nous avons considéré les tables « *mensuration* » et « *production* » dans le calcul des quantités débarquées.

3. Résultats

3.1 Analyse descriptive des données

De façon générale, les données historiques et récentes disponibles ont été collectées à Abidjan, en particulier sur les sites du port de pêche, de Zimbabwe et d'Abobo-Doumé (**Figure 1**). Les données provenant des enquêtes effectuées sur les sites de débarquement à San-Pedro et Sassandra ne représentent qu'une proportion relativement faible de l'ensemble. La disponibilité des données sur les différentes années se repartie comme indiqué dans le **Tableau 3**.

En dehors d'Abidjan où trois sites de collecte de données ont été identifiés, les 2 autres zones (San-Pedro et Sassandra) ne disposent qu'un seul site de débarquement. Le site du port de pêche a fait l'objet d'un suivi régulier du débarquement depuis 1984, contrairement à ceux d'Abobo-Doumé et de Zimbabwé où les pirogues ont commencé à depuis seulement 2005.

Pour ce qui concerne San-Pedro et Sassandra, le suivi des débarquements des thonidés mineurs n'a été effectué que sur trois années seulement, entre 2002 et 2004 pour San-Pedro et en 2002, 2005 et 2006 pour Sassandra.

- *Nombre de jour d'observation par an*

L'exhaustivité des formulaires papier est très difficile à prouver. En effet, des sauts de dates correspondant à des jours potentiels d'observations peuvent ne pas être disponibles parce que :

- L'enquêteur n'avait pas fait d'observation ces jours-là (pas de données) ;
- L'enquêteur avait fait des observations mais les fiches d'enquêtes ont été perdues.

A certaines périodes, les enquêteurs ont pris le soin de renseigner l'absence de collecte d'information en utilisant des formulaires vierges uniquement datées.

Le nombre de jour d'observation annuel a été utilisé comme un indicateur de l'importance du nombre de données collectées, sous l'hypothèse que les enquêteurs travaillent 5 jours par semaine, ce qui correspond à 260 jours d'observation par an, hormis les jours fériés, soit environ 250 jours d'observation effectifs.

Les années 1984 à 1987 marque la mise en place du système de collecte de données au Port de pêche d'Abidjan. Ce qui traduit la faible quantité d'information annuelle. Les nombres de jours d'observation par an restent cohérents entre 1988-2004 avant de chuter à partir de 2005. La faiblesse du nombre de jours d'observation pourrait s'expliquer par le changement de site de débarquement des pêcheurs artisans. Malgré tout le nombre de jours d'observations sur les sites d'Abobo-Doumé et de Zimbabwé n'atteint pas les 250 jours par an depuis plus de 5 ans. Selon les enquêteurs, cette diminution du nombre de jours de débarquements est due au fait que les jours passés en mer ont augmenté ces dernières années. Ces variations pourraient être assimilés à des changements de comportement des pêcheurs qui ont auraient adopté cette stratégie s'adaptation face à la raréfaction des poissons et/ou des conditions de pêche. Cependant, contrairement aux sites de débarquements d'Abidjan, ceux de San-Pédro et de Sassandra font l'objet d'un suivi assez irrégulier, simplement à cause du manque de personnel d'enquêtes. Le critère du nombre de jours d'observation ne permet finalement pas de valider le manque éventuel de données.

- *Aspects quantitatif et qualitatif des données collectées*

La comparaison des **Figures 2 et 3** montre que les mensurations n'ont débuté qu'en 2000 pour les petits thonidés alors que les productions existent depuis 1984. Ceci confirme le caractère non prioritaire, dans les enquêtes d'autant plus qu'au début, les espèces étaient surtout mesurées.

3.2 Captures, effort et taille (Tâche I et II de l'ICCAT)

Les résultats issus des traitements des données ont été enregistrés dans trois fichiers différents au format Excel.

1. Les données de TACHE I (**T1NC.xls**)
2. La tâche II des prises et effort (**T2CE.xls**)
3. La tache II des échantillons de tailles (**T2SZ.xls**)

Les données sont enregistrées dans le document **ICCAT_SMT_TACHE_I & II** joint à ce rapport.

4. Discussion

- *Limites du travail*

La validité de ce travail et des résultats qui y sont produits sont conditionnés par les hypothèses effectuées dans le traitement et les interprétations qui en découlent. Les difficultés rencontrées ont porté essentiellement sur la récupération des données historiques du fait de leur caractère éparse. Hormis, la vérification puis validation des saisies, aucun critère objectif n'a pas permis de déceler un manque de données. Il faut souligner qu'aucune étude bibliographique n'a été faite pour tenter d'obtenir des informations ou données complémentaires du fait du manque de temps. En effet, la saisie a été plus chronophage que prévue et le temps de saisie a finalement été multiplié par trois.

- *Intérêt du projet*

Ce projet sur la récupération des données a été d'un intérêt certain à plusieurs niveaux. Pour l'ICCAT, ce projet a permis de faire une mise à jour des données historiques sur les thonidés mineurs. Pour le Centre de Recherches Océanologiques d'Abidjan, ce projet a permis de mobiliser des moyens (financiers et humains) afin d'effectuer la récupération de ces données historiques. Le gain porte également sur le traitement des données actuelles car ce projet a permis de créer une base de données de saisie, permettant une saisie cohérente et globale des données collectées. Le dernier point d'intérêt de ce projet est qu'il a permis de mettre en évidence la faiblesse de la stratégie d'échantillonnage. En effet, les données déclarées depuis plusieurs années ne sont qu'une fraction des productions du pays. Il s'agit des débarquements d'Abidjan qui constituent la fraction la plus accessible à moindre coût.

- *Aspects quantitatif et qualitatif des données collectées*

La faiblesse du nombre de jours d'observation sur les thonidés mineurs entre 1992 et 2000 pourrait traduire des stratégies variables dans la collecte des données, au cours de cette période. Ce constat n'est vraisemblablement pas dû à la perte d'information puisque tous les formulaires de production de cette période sont disponibles. Il pourrait donc se traduire par des stratégies d'échantillonnage prioritaire portant sur d'autres espèces que les thonidés mineurs (certainement les gros individus comme les istiophoridés et les requins) pour des raisons de projets spécifiques ou de manque de personnel. Ceci est moins vrai ces dernières années où la collecte de données porte sur l'exhaustivité des espèces y compris les thonidés mineurs.

5. Conclusion et perspectives

La pêche artisanale maritime en Côte d'Ivoire se pratique sur l'ensemble du littoral ivoirien dont la longueur est d'environ 550 km. C'est une pêche qui opère en particulier en deçà des deux miles marins du plateau continental. Les estimations font état d'une dizaine de milliers de pêcheurs artisans répartis sur tout le littoral ivoirien depuis Assinie-Mafia à l'Est jusqu'à Tabou à l'Ouest. Or les statistiques actuelles ne portent que sur quelques centaines de pirogues, débarquant essentiellement dans les ports Abidjan.

Ce projet portant la récupération des données historiques révèle plus que jamais la nécessité de renforcer et consolider le système de collecte de données de la pêche artisanale en Côte d'Ivoire. La consolidation et la fiabilité du système de collecte de données, à grande échelle, nécessite l'élaboration d'un plan d'amélioration de la collecte des données. Ceci passe par :

- *Identification des sites prioritaires d'échantillonnage*

Les données occasionnelles provenant de San-Pédro et Sassandra ont été le fruit d'une présence à un moment données d'enquêteurs sur ces sites pour le suivi des captures. Il existe pourtant des sites identifiés comme étant des lieux de débarquements importants de la pêche artisanale sur l'ensemble du littoral ivoirien. Il convient donc de faire un état des lieux de ces sites afin d'élaborer un système de collecte de données optimal à l'échelle de la façade maritime ivoirienne.

- *Renforcement des équipes*

Le problème actuel auquel est confronté le CRO dans la collecte des données réside dans le manque de personnel. Ces trois dernières années ont vu le recrutement de chercheurs qualifiés pour traiter de ces thématiques mais le pool de techniciens reste relativement faible. Cependant, des services techniques de l'Etat, comme la Direction des Pêches disposent du personnel pouvant contribuer à la mise en œuvre d'un programme national de collecte de données de la pêche maritime. Il convient donc pour nous d'envisager plus sérieusement cette approche qui semble la plus efficace d'autant plus que le CRO et la DAP ont cet intérêt commun de collectes de données fiables et pérennes.

- *Suivi de la collecte des données*

Le suivi de la collecte de données permettra de vérifier le bon fonctionnement du système de collecte. Il permettra aussi de l'ajuster au fur et à mesure afin de le rendre plus fiable.

Au final, un plan d'amélioration des données de la pêche en Côte d'Ivoire, notamment de la pêche artisanale nécessite une augmentation du nombre d'enquêteurs disponibles actuellement. Cela passe par une contribution nationale importante à travers le recrutement et la prise en charge du personnel qualifié dans les zones encore vierges et ou par la mise en commun des techniciens des différents services de l'Etat pour plus d'efficacité et moins de redondances. Malgré tout, le nombre de personne nécessaire n'est pas le seul facteur limitant qui justifie la faiblesse du système actuel. Les financements nécessaires n'y sont pas. Nous proposons donc à l'ICCAT de mettre en place, dans un premier temps, un financement nécessaire à l'élaboration du projet pilote d'identification des sites prioritaires et de la définition de plan d'échantillonnage au niveau national. Après cette phase, l'ICCAT pourra ensuite mettre en place un financement annuel de collecte de données de pêche, permettant de :

- Former des enquêteurs ou de mettre à jour leur formation
- Contractualiser des enquêteurs supplémentaires
- Acheter et mettre à disposition du matériel de collecte de données
- Assurer le suivi et l'évaluation

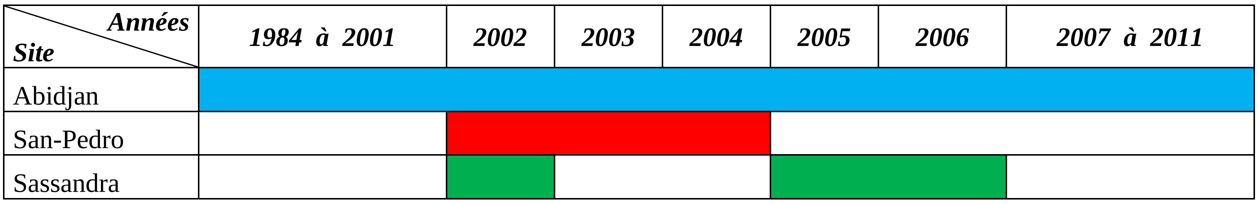
Tableau 1 : Séries manquantes de taille, de prise et d'effort de la tâche II des thonidés mineurs dans la base de données ICCAT.

Code espèce	Nom français	Nom scientifique	Séries manquantes par type de statistique	
			Prise et effort	Taille
FRI	Auxide	*Auxis thazard*	1990 à 2006 2008 à 2011	1990 à 2006 2008 à 2011
LTA	Thonine commune	*Euthynnus alletteratus*	1990 à 2006 2008 à 2011	1990 à 2006 2008 à 2011
BON	Bonite à dos rayé	*Sarda sarda*	1990 à 2006 2008 à 2011	-1990 à 2011--
MAW	Thazard blanc	*Scomberomorus tritor*	1990 à 2011	1990 à 2011
WAH	Thazard batard	*Acanthocybium solandri*	1990 à 2011	1990 à 2011

Tableau 2 : Paramètres a et b et poids moyens utilisés pour la conversion des tailles et des nombres en poids.

CODE	NOM_SCIENTIFIQUE	a	b	SOURCE	Poids moyen (en kg)
WAH	*Acanthocybium solandri*	0.0004186	2.0871373	Données actuelles	6.100912
BLT	*Auxis rochei*	0.00358	3.435	www.fishbase.org	1.359642
FRI	*Auxis thazard*	0.00001264	3.065	Données actuelles	1.347657
LTA	*Euthynnus alletteratus*	0.0002375	2.3285353	Données actuelles	1.371627
BON	*Sarda sarda*	0.00001537	2.975	Données actuelles	1.012002
MAW	*Scomberomorus tritor*	0.00001737	2.836	Données actuelles	0.966612
FRZ	Auxides/Thonines	---	---	---	1.359642

Tableau 3 : Disponibilité annuelle des données selon le site de débarquements.



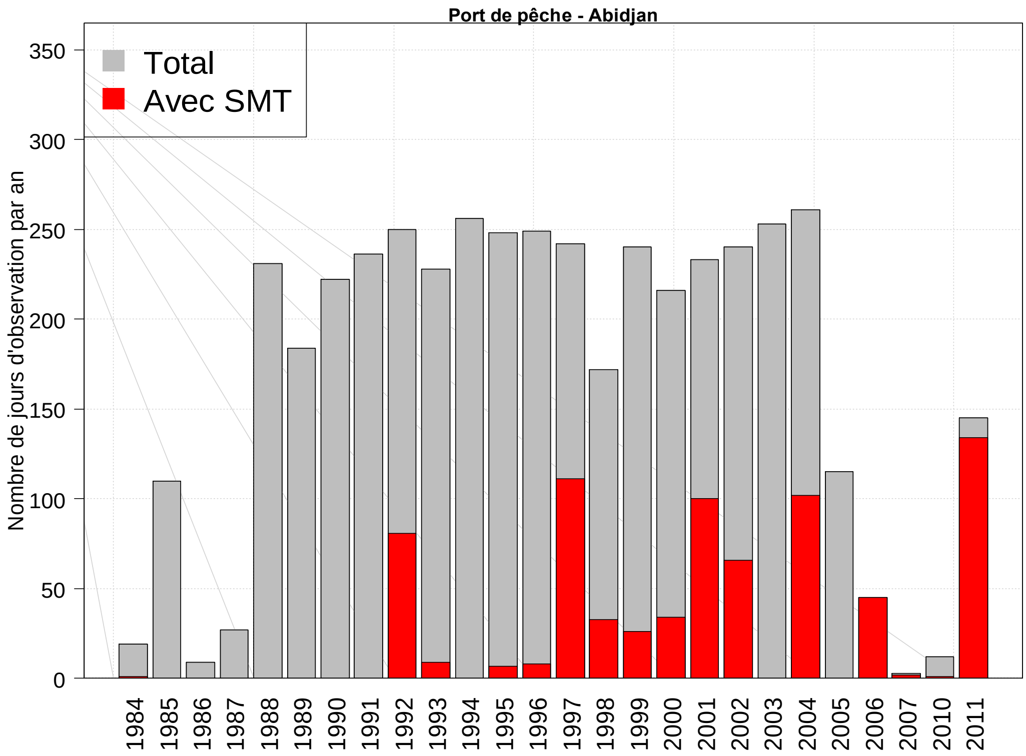


Figure 1 (a) : Nombre de jours d'observation par an au port de pêche d'Abidjan.

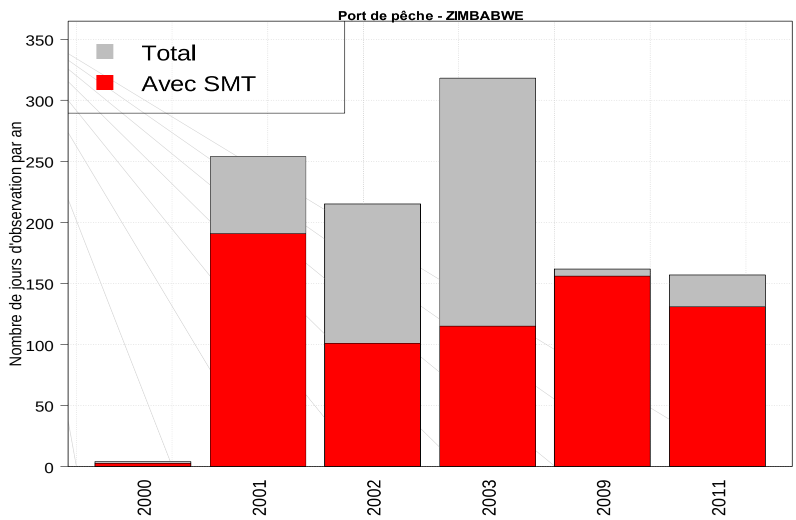


Figure 1 (b) : Nombre de jours d'observation par an au port de débarquement d'Abobo-Doumé.

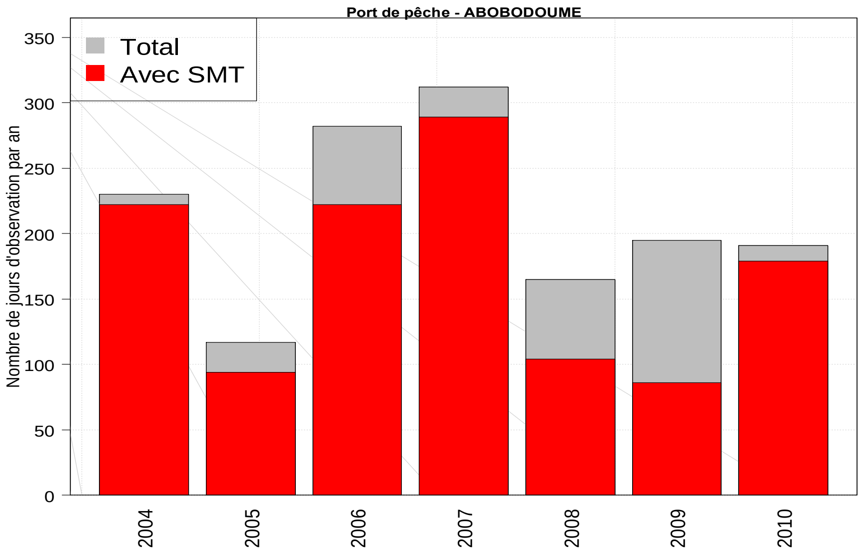


Figure 1 (c) : Nombre de jours d'observation par an au port de débarquement d'Abobo-Doumé.

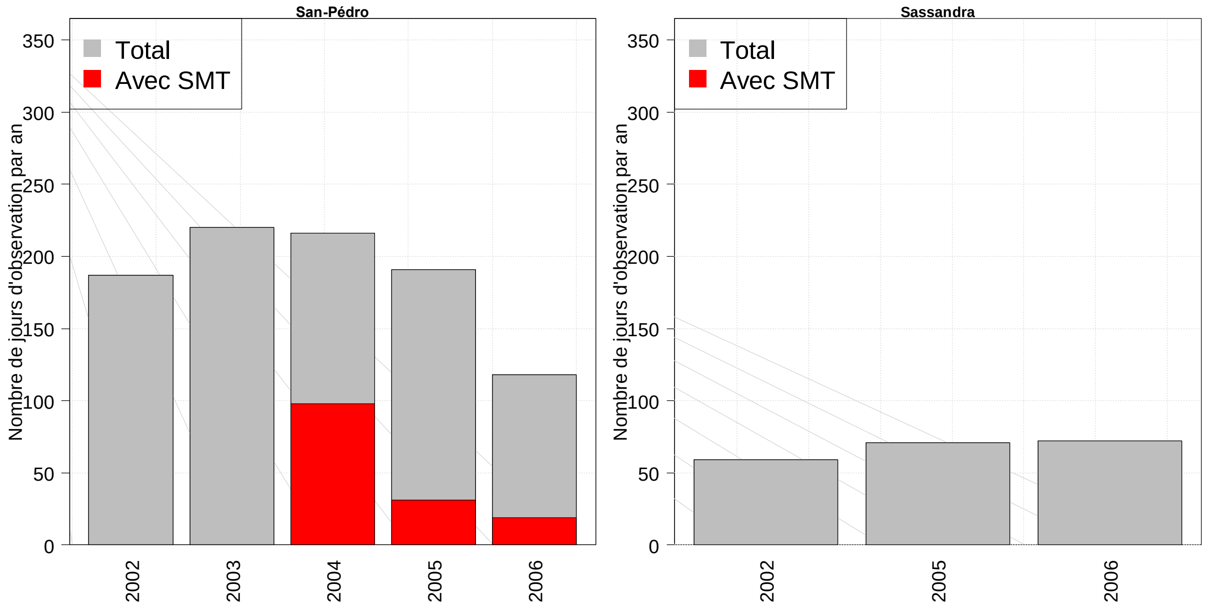


Figure 1 (d) : Nombre de jours d'observation par an au port de débarquement de San-Pédro et Sassandra.

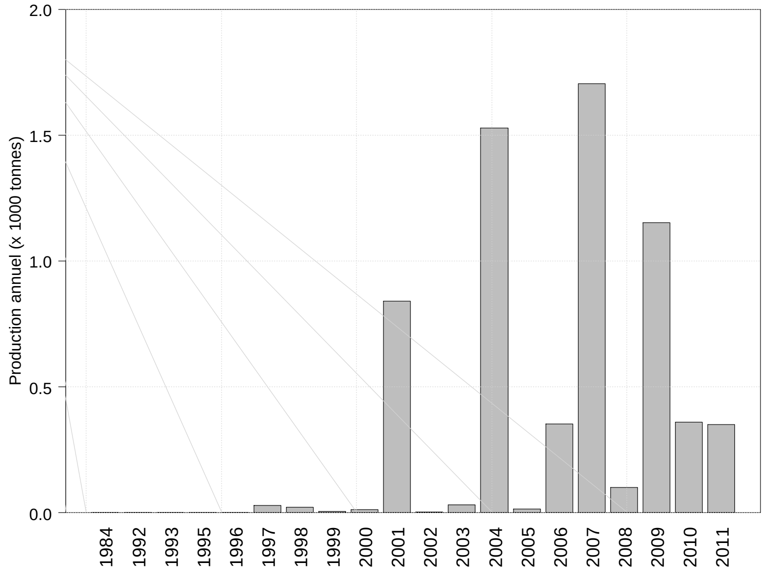


Figure 2 : Production totales (en tonnes) des thonidés mineurs.

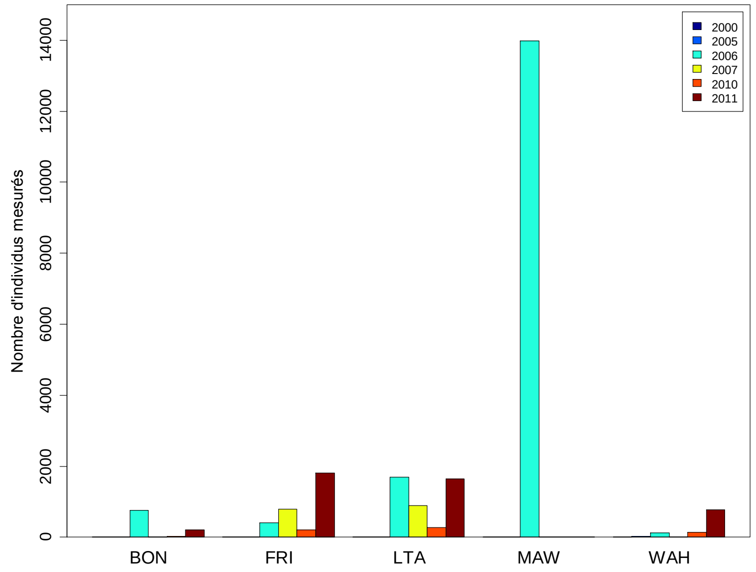


Figure 3 : Nombre d'individus mesurés selon les espèces et les années.

Annexe 1

Description des champs des tables de saisie

Mensuration	Production	Effort	Description des champs
SITE_DBQ	SITE_DBQ	SITE_DBQ	Site de débarquement
NOM_ENQUETEUR	NOM_ENQUETEUR	NOM_ENQUETEUR	Nom de l'enquêteur
PRENOMS_ENQUETEUR	PRENOMS_ENQUETEUR	PRENOMS_ENQUETEUR	Prénoms de l'enquêteur
ANNEE_OBS	ANNEE_OBS	ANNEE_OBS	Année de l'observation
MOIS_OBS	MOIS_OBS	MOIS_OBS	Mois de l'observation
JOUR_OBS	JOUR_OBS	JOUR_OBS	Jour de l'observation
NOM_BATEAU	NOM_BATEAU	NB_BAT_SORTIE	Nombre de bateaux sortis
NUM_BATEAU	NUM_BATEAU	NB_BAT_DBQ	Nombre de bateaux sortis
TYPE_BATEAU	TYPE_BATEAU	TYPE_BATEAU	Le type de bateau
TYPE_ENGIN	TYPE_ENGIN		Le type d'engin
NOM_ESPECE	NOM_ESPECE		Nom de l'espèce
V_LF			Longueur à la fourche (cm)
V_POIDS			Poids
V_SEXE			Sexe
NB_BAT_SORTIE	NB_BAT_SORTIE		Nombre de bateaux sortis le jour de l'observation
NB_BAT_DBQ	NB_BAT_DBQ		Nombre de bateaux entrés ou qui vendent le jour de l'observation

Annexe 1

Description des champs des tables de saisie (suite)

Mensuration	Production	Effort	Description des champs
	NB_LOT		Nombre de lot
	TYPE_LOT		Type de lot
	NB_IND_PAR_LOT		Nombre d'individus par lot
	NB_TOT_DBQ		Nombre total d'individus débarqués
	POIDS_PAR_LOT		Poids par lot
	POIDS_TOT_DBQ		Poids total débarqué
L_COMMENT	L_COMMENT	L_COMMENT	Commentaire

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PROGRAMME DE RECHERCHE SUR LES THONIDES MINEURS RECUPERATION DES DONNEES HISTORIQUES DE THONS MINEURS CAPTURES PAR LA PECHE ARTISANALE AU SENEGAL

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SUMMARY

This report is produced within the framework of the research programme on small tunas initiated in 2013 by ICCAT. The report presents the collection of estimates, identification, historical data recovery and validation for small tunas from 1990 to 2012 caught by the major artisanal fishing gears in Senegal. This refers to data on the artisanal fleet, catch, effort and size for the four major species: little tunny, Atlantic bonito, West African Spanish mackerel and frigate tuna targeted or caught as bycatch by the major artisanal fishing gears. Data were collected at the main artisanal fishing landing ports by researchers of the Centre de Recherches Océanographiques de Dakar Thiaroye-CRODT (Center of Oceanographic Research of Dakar-Thiaroye). Thereafter a synthetic analysis is carried out on recovered data.

RESUME

Ce rapport est produit dans le cadre du programme de recherche sur les thonidés mineurs lancé en 2013 par l'ICCAT. Le rapport présente les méthodologies de collecte d'estimation, d'identification, de récupération et de validation des données historiques de thonidés mineurs de 1990 à 2012 capturés par les principaux engins de pêche artisanale au Sénégal. Il s'agit des données relatives à la flottille artisanale, aux captures, à l'effort et aux tailles des quatre principales espèces : thonine, bonite à dos rayé, thazard blanc et auxide capturées de façon ciblée ou accessoire par les principaux engins de la pêche artisanale. Les données ont été collectées au niveau des principaux ports de débarquements de la Pêche artisanale par les enquêteurs du Centre de Recherches Océanographiques de Dakar/ Thiaroye (CRODT). Par la suite une analyse synthétique est faite sur les données récupérées.

RESUMEN

Este informe se presenta en el marco del programa de investigación sobre pequeños túnidos iniciado en 2013 por ICCAT. Este informe presenta las metodologías de recopilación, de estimación, de identificación, de recuperación y de validación de datos históricos de pequeños túnidos desde 1990 a 2012 capturados por los principales artes de pesca artesanal en Senegal. Se trata de datos relativos a la flota artesanal, a las capturas, al esfuerzo y a las tallas de cuatro especies principales: bacoreta, bonito, carita oeste africano y melva, capturados como especie objetivo o de captura fortuita por los principales artes de la pesca artesanal. Los datos han sido recopilados por los encargados del Centro de investigación oceanográfica de Dakar Thiaroye (CRODT) en los principales puertos de desembarque de la pesca artesanal. A continuación se realiza un análisis sintético de los datos recuperados.

KEYWORDS

Statistiques, Sénégal, Pêche artisanale, Thonidés mineurs, Méthodes d'estimation et validation

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1. Contexte et objectifs de la mission

1.1 Bref rappel du contexte de la mission

Dans le but d'améliorer la collecte des données statistiques et biologique de base des thonidés mineurs, un programme de recherche sur les thonidés mineurs a été adopté par le SCRS en 2011 et par la Commission en 2012. Dans ce cadre, l'ICCAT compte mettre en œuvre la première phase dudit programme qui consiste à récupérer les données historiques sur ces espèces ne figurant pas dans la base de données de l'ICCAT. Le présent dossier de candidature entre dans ce cadre en vue de la récupération des données historiques sur les thonidés mineurs exploités par les pêcheries sénégalaises.

1.2 Objectifs de la mission

L'objet global est de récupérer des séries temporelles historiques de toutes les pêcheries opérant dans la zone de la Convention ICCAT ciblant les thonidés mineurs ou les capturant accessoirement.
Les objectifs spécifiques de la mission sont :

- Récupération et soumission des données de thonidés mineurs ;
- Description de la méthodologie utilisée pendant le processus de validation ;
- Fourniture des données dans le format défini par le Secrétariat de l'ICCAT
- Soumission de la documentation des jeux de données ;
- Présentation d'un rapport détaillé de chaque jeu de données.

2. Collecte et estimation des données de pêche artisanale

2.1 Collecte des données de pêche artisanale

En pêche artisanale, le dispositif de collecte des données du CRODT est principalement axé sur trois types d'opérations. Il s'agit du recensement du parc piroguier et des engins de pêche, du relevé de l'effort de pêche et de l'enquête sur les captures et sur les tailles des principales espèces. Le recensement a lieu deux fois par an (saison froide et saison chaude). Le recensement est effectué par les enquêteurs de la pêche artisanale appuyés par une équipe mobile de chercheurs et de techniciens. Les informations collectées ont trait, entre autres, aux centres d'attache et d'origine de la pirogue, à la taille de l'équipage, à la puissance du moteur, aux engins utilisés, etc. Les enquêtes permanentes sur l'effort de pêche, les captures et les tailles des espèces débarquées par la pêche artisanale sont effectuées au niveau des huit principaux centres de débarquement (Saint Louis, Kayar, Yoff, Ouakam, Soumbédioune, Hann, Mbour et Joal) qui constituent les sites traditionnels d'échantillonnage du CRODT (**Figure 1**).

L'effort est collecté par des aides de plage qui s'informent quotidiennement sur le nombre de sorties en mer selon l'engin de pêche. A cet effet, trois procédés liés à la physionomie de chaque centre sont habituellement utilisés. Il s'agit du pointage, du double comptage et de l'interview. Pour la méthode du pointage, à partir d'un point précis du site débarquement, l'aide de plage repère et compte toutes les pirogues qui viennent débarquer en prenant le soin de tenir compte de l'engin de pêche. Ainsi, à la fin de la journée, l'effort de pêche correspond au nombre de pirogue comptées par engin. En ce qui concerne le double comptage, l'aide de plage visite très tôt toute la plage avant le départ des pirogues pour la mer. Il compte alors toutes les pirogues à quai en fonction de l'engin utilisé. Ensuite, plus tard dans la journée il revient pour faire un nouveau comptage. En faisant la différence entre ces deux comptages, l'aide de plage détermine le nombre effectif de sorties qui correspond donc à l'effort. Enfin, pour la méthode de l'interview, dans chaque site de débarquement, l'aide de plage effectue un entretien avec les vieux pêcheurs qui sont en permanence au niveau de la plage pour assister les pêcheurs au départ et à l'arrivée des pirogues. Ces vieux qui connaissent parfaitement toutes les pirogues du site indiquent alors à l'aide de plage le nombre effectif de sorties selon l'engin de pêche. Il faut noter que dans certains cas, ces trois méthodes peuvent être combinées dans un centre donné afin de valider et compléter les informations.

Pour les captures, la collecte des données se fait en échantillonnant de manière aléatoire les pirogues au moment du débarquement. L'enquêteur tient cependant compte de l'engin de pêche qui constitue avec le centre de débarquement et la quinzaine et l'une des trois strates essentielles à l'estimation globale des captures. Cette stratification croisée permet en effet de mieux prendre en compte les fluctuations spatio-temporelles et les spécificités de chaque type de pêche. Pour chaque pirogue échantillonnée, l'enquêteur s'informe d'abord auprès du capitaine sur les caractéristiques de la sortie à savoir notamment, l'engin utilisé, le nombre de pêcheurs embarqués, le lieu de pêche fréquenté, la profondeur de pêche et la durée de la sortie. Ensuite, pour chaque espèce de la pirogue, l'enquêteur évalue la quantité capturée en prenant en compte la quantité débarquée et les éventuels rejets qui sont cependant très rares dans la pêche artisanale. Cette évaluation des quantités débarquées se fait soit à travers le pesage, l'estimation à vue ou à travers les renseignements du capitaine et du mareyeur. Enfin, pour les principales espèces, l'enquêteur tire un échantillon aléatoire de quelques individus dont il mesure les tailles.

2.2 Processus de saisie des données

La saisie des données se fait dans le Bureau Calcul du CRODT qui est doté d'infrastructures adaptées à la saisie et à la gestion de grandes masses de données (**Figure** 2**2**). Il s'agit notamment d'équipements informatiques performants reliés par un réseau intranet constitué de quatre principales composantes. La première composante correspond à un ensemble d'ordinateurs PC qui constituent les postes de travail de l'équipe d'opérateurs de saisie. Ensuite un deuxième ensemble d'ordinateurs PC permet de prendre en charge le traitement et la consultation des données saisies. Pour la sauvegarde sécurisée des données et des applications, une armoire Rack est disponible pour abriter plusieurs outils technologiques essentiels. Il s'agit notamment de deux serveurs de base de données, d'un serveur proxy, d'un serveur applicatif, d'un contrôleur de domaine, des unités de sauvegarde et d'un onduleur qui assure la stabilité électrique. Enfin, la quatrième composante est l'imprimante centrale qui permet d'imprimer les listings de vérification des données.

Il faut tout d'abord noter qu'au sein du CRODT existe une application de gestion intégrée de l'ensemble des données dénommée SINAP (Système d'Information Nationale sur la Pêche). Cette application intègre différents écrans permettant l'accès sécurisé au système ainsi que la saisie, la consultation et la vérification des données. Le processus de saisie et de traitement des données de la pêche artisanale est pris en charge par cette application.

Après un contrôle manuel des fiches la saisie des données d'enquête de la pêche artisanale se fait à travers une interface spéciale comportant quatre entités en relation (**Figure** 3**3**). La première entité comprend les variables d'identification telles que la zone maritime, le centre de débarquement, l'enquêteur et la date d'enquête. La deuxième entité correspond au relevé d'effort en nombre de sortie par engin pour chaque jour dans un centre donné. Elle est suivie par la caractérisation de la sortie de chaque pirogue échantillonnée au moment du débarquement. On y retrouve des variables telles que le nombre de pêcheurs à bord, le lieu de pêche, la profondeur de pêche et la durée de la sortie. La quatrième entité permet de saisir les captures et les fréquences de tailles des espèces trouvées dans chaque pirogue échantillonnée.

2.3 Procédure d'estimation des statistiques de pêche

L'estimation des statistiques de la pêche artisanale (effort et captures notamment) se fait à travers une procédure comportant plusieurs étapes de calcul aussi bien sur les données de recensement que sur les enquêtes (**Figure 4**). Cette procédure d'estimation de l'effort et des captures de la pêche artisanale est entièrement automatisée à travers des routines développées sous le logiciel SPSS.

Tout en permettant de faire l'état du parc piroguier et des engins de pêche, le traitement des données du recensement permet de calculer les coefficients d'extrapolation qui servent à estimer l'effort et les captures par région maritime. Ces coefficients sont calculés pour chaque région maritime selon l'engin (ou groupe d'engins) et la saison (froide et chaude). Pour une région *R* donnée, le coefficient d'extrapolation régional se calcule à travers la formule suivante :

$$CE_R = \frac{U_R}{u_R} \qquad (1)$$

(1) U_R est le nombre d'unités de pêche recensées (principalement des pirogues mais aussi prise en compte de la pêche à pied) dans toute la région R.

(2) u_R est le nombre d'unités de pêche recensées (principalement des pirogues mais aussi prise en compte de la pêche à pied) dans tous les ports régulièrement couverts par le dispositif d'enquête dans la région R.

Le traitement des données d'enquête au débarquement s'inscrit principalement dans le cadre d'une procédure de calcul aboutissant à l'estimation de l'effort et des captures au niveau de chaque centre d'enquête et de la région maritime. Dans un premier temps, pour chaque centre et pour chaque engin de pêche, l'effort de pêche (exprimé en nombre de sorties) est cumulé puis agrégé par quinzaine en tenant compte du nombre de jours sans collecte d'effort dans la quinzaine à travers un facteur d'ajustement $\frac{J}{j}$. Ainsi, pour chaque engin de pêche, la formule suivant sert à calculer l'effort dans un centre d'enquête *C* durant une quinzaine donnée.

$E_C = \frac{J}{j} \sum_{i=0}^{J} e_{iC}$ (2)

(3) e_{iC} est l'effort de pêche (nombre total de sorties) relevé au cours de la quinzaine dans le centre *C*.
(4) *J* est le nombre total de jours de la quinzaine considéré. Pour chaque mois, *J=15* pour la première quinzaine. Pour contre, pour la deuxième, le nombre de jours varie en fonction du mois (15 jours pour les mois à 30 jours, 16 jours pour les mois à 31 jours et 13 ou 14 jours pour le mois de février).
(5) *j* est le nombre total de jours de la quinzaine durant lesquels l'effort a été relevé dans le centre en question. En Príncipe, l'effort est collecté tous les jours dans chaque centre; et donc théoriquement $j = J$ et $\frac{J}{j} = 1$. Cependant pour une raison quelconque (par exemple maladie ou contrainte sociale des aides de plages) il peut arriver qu'il y'ait quelques jours dans la quinzaine sans collecte d'effort ($j < J$). C'est la nécessité d'ajuster ces genres de situations qui justifie le facteur d'ajustement $\frac{J}{j}$.
Pour les captures, les données issues de l'enquête permettent d'abord d'estimer pour chaque espèce (ou groupe d'espèces) les captures par unité d'effort (cpue en kg par sortie) par quinzaine et par engin. Ensuite, la multiplication des captures par unité d'effort (CPUE) avec l'effort agrégé aboutit à la détermination des captures extrapolées par centre. Pour chaque engin, la formule suivante est utilisée pour calculer la captures débarquées (ou encore débarquements) de l'espèce dans le centre *C* durant la quinzaine considérée.
$D_C = E_C \text{ x } CPUE_C = E_C \text{ x } \frac{d_C}{n_c}$ (3)
(6) d_c est la quantité totale débarquée de l'espèce en question par l'ensemble des pirogues ayant utilisé l'engin considéré durant la quinzaine dans le centre *C*.
(7) n_c est le nombre total de pirogues échantillonnées ayant utilisé l'engin considéré durant la quinzaine dans le centre *C*.
Enfin, l'utilisation des coefficients d'extrapolation régionaux en fonction de la saison et des groupes d'engins permet l'estimation des statistiques de pêche (effort et captures) au niveau régional et national. Cette procédure se fait à travers les formules suivantes :

Pour la région *R*, en considérant l'ensemble des centres d'enquête :
l'effort total est $E_R = CE_R \text{ x } \sum_c E_c$ (4)
et la capture totale débarquée est $D_R = CE_R \text{ x } \sum_c D_c$ (5)
Au niveau national *R*, en considérant l'ensemble des régions d'enquête :
l'effort total est $E = \sum_R E_R$ (6)
et la capture totale débarquée total est $D = \sum_R D_R$ (7)

3. Identification, récupération et validation des données

3.1 Identification des données récupérées

Les données de la pêche artisanale sont relatives à l'effort, aux prises et aux tailles. Les données d'effort sont exprimées en nombre de sorties par engin, par mois et par zone. Elles couvrent la période 1990-2012. En ce qui concerne les prises, elles concernent la thonine *(Euthynnus alletteratus)*, l'auxide *(Auxide thazard)*, le bonite à dos rayé (*Sarda sarda)* et le thazard blanc (*Scomberomerus tritor) (Tâche I et II)*. Ces données de captures couvrent également la période 1990-2012. Les données de taille sont structurées par engin, par mois et par zone (port de pêche). Elles couvrent la période 1990-2012. Les données de taille sont relatives à la thonine *(Euthynnus alletteratus)*, à l'auxide *(Auxide thazard)*, au bonite à dos rayé (*Sarda sarda)* et au thazard blanc (*Scomberomerus tritor)*. Toutes les données sont stockées de manière dispersée dans différents supports (serveurs, ordinateurs, discs amovibles, etc.).

3.2 Récupération des données

Les données récupérées dans le cadre de ce travail sont celles qui ne se trouvent actuellement dans la base de données de thons mineurs de l'ICCAT. En effet, les données existantes dans la base de données de l'ICCAT sont celles des prises et d'effort de la tâche II de la thonine et l'auxide des canneurs sénégalais de 2005 à 2011. Ainsi, à partir d'un recoupement entre la base de données de l'ICCAT et les différentes archives et bases de données du CRODT, les données manquantes ont été identifiées.

Les données ont été recherchées dans différentes sources. Il s'agit essentiellement de la base de données du CRODT dans lesquelles sont stockées des masses importantes de données historiques. Ces données ont été comparées et au besoin complétées par le biais de l'exploration d'autres supports. A cet effet, les collègues qui travaillent sur de telles données ont été consultés pour faciliter le processus. La récupération et la compilation des données ont été faites à travers des routines sous le logiciel SPSS. Les données ont été ensuite converties en format Excel pour faciliter la procédure de soumission à travers les formulaires de l'ICCAT.

3.3 Validation des données récupérées

La validation des données a été basée sur une l'exploration et le contrôle des données récupérée. Ce diagnostic permet de rechercher certaines lacunes, en particulier des données manquantes ou aberrantes. A cet effet, des tris croisés ont été effectués pour examiner les différentes valeurs des variables. Des courbes ont été également tracées pour détecter d'éventuelles irrégularités. Les quelques lacunes identifiées ont été surtout relatives à des données manquantes. Ainsi, des corrections ont été apportées en recherchant des données complémentaires à travers des discutions avec les personnes impliquées dans la collecte et le traitement des données. Ainsi, outre la base de données centrale du CRODT, des données provenant de disques de sauvegarde ont permis de compléter les séries de données. Les données validées ont été ensuite soumise dans la base de données de l'ICCAT. En outre, une analyse synthétique a été effectuée sur les différentes composantes des données (flottille de pêche, captures et tailles des espèces concernées).

4. Processus de soumission des données récupérées

4.1 Soumission des données sur la flottille de pêche

Les effectifs des principaux engins sont présentés dans le **Tableau 1** du présent rapport. Les engins sont répartis en Ligne traine (TROL), lignes(Handline), autres engins (OTH) et filets (Gillnets).

4.2 Soumission des données sur de captures des espèces

Les données récupérées seront présentées sous le format électronique de l'ICCAT. En effet, pour la soumission des données, nous avons utilisé les formulaires de l'ICCAT relatifs à la tâche I (prises nominales) et tâche II (Prises et effort) par mois /engin/Zone de pêche et par année (1990-2012).

4.3 Soumission des données de tailles des espèces

Les données d'échantillonnage de taille des 4 espèces (MAW, BON, LTA et FRI) sont aussi soumises sous le format électronique de l'ICCAT de 1990 à 2012 pour MAW, BON, LTA et 2004 à 2012 pour FRI. Pour chaque espèce, les tailles sont ventilées par année /mois/engin/zone de pêche année.

5. Analyse Synthétique des données récupérées

5.1 La flottille de pêche

Le **Tableau 1 et la Figure 5** montrent l'évolution des engins de pêche. L'évolution du nombre total des principaux engins capturant de façon ciblée et accessoire montre une tendance à la hausse depuis les années 90. Il est à noter que les vides correspondent aux années où les recensements de la flottille artisanale n'ont pas été conduits. Les Années 1997 et 2005 représentent celles où le recensement a couvert tout le littoral sénégalaise ce qui justifie les nombre élevés de ces deux années. L'évolution de chaque engin est illustrée par la **Figure 6**. Le nombre des lignes traines ciblant les thons mineurs est resté relativement stable de 1997. Par contre les lignes à la main (ciblent les SMT) et les filets (capturent accessoirement les SMT) montre une tendance à la haussent depuis 1990.

5.2 Les captures des espèces

La **Figure 7** montre l'évolution de captures globales par espèce de 1990 à 2012. On note de très fortes oscillations des captures. La thonine a été sur toute la période de 1990 -2012, l'espèce la plus dominante dans les captures, suivi de la bonite à dos rayé (BON), du thazard blanc (MAW) et de l'auxide (FRI).

L'analyse de la **Figure 8** montre que les filets débarquent les quantités les plus importantes de thonidés mineurs. Ils les capturent de façon accessoire. Les filets ont réalisés 80 % des captures de l'auxide, 80 % du thazard blanc, 70 % de la thonine et 60 % de la bonite à dos rayé.

La Figure 9 montre distribution des captures par zones de pêche. On constate que le Maw est principalement capturé dans la Petite Côte (Mbour Joal) , la thonine, la bonite à dos rayé au Cap Vert (Yoff, Soumbédioune) et dans la Grande Côte (Cayar surtout). L'auxide est principalement capturé au Cap Vert.

Les figures 10 et 11 montrent les distributions mensuelles des tailles de MAW, LTA, BON et FRI sur toute la période 1990 à 2012 sauf pour FRI la série commence en 2004. On note une certaine variabilité des tailles capturées par mois.

Conclusion

Les captures des thonidés mineurs surtout la thonine et la bonite à dos rayé constituent une part importante dans les captures des engins de pêche artisanale. Il est à souligner que les données présentées dans ce document ne couvrent pas la totalité des lieux de pêche de la pêche artisanale. De ce fait, il serait nécessaire d'étendre la collecte des données vers la partie Sud. Il est à noter aussi que l'effort de pêche des filets et autres engins n'est dirigé sur ces thons mineurs, ils les capturent de façon accessoire. L'amélioration de l'intensité de l'échantillonnage des tailles des espèces de thons mineurs au niveau des ports de débarquement est fortement recommandée.

Tableau . Répartition du nombre des engins par année.

Année	*Ligne traine*	*Autres lignes*	*Filets*	*Autres engins*
1990		3790	1886	80
1991		3396	1603	19
1992		3673	2060	18
1993		3497	1883	24
1994		3783	1396	27
1995		4172	2486	66
1996				
1997	122	5089	5367	1737
1998				
1999				
2000				
2001	188	4910	3248	35
2002	183	6193	3328	54
2003				
2004	176	5178	3657	120
2005	278	7299	7911	2000
2006				
2007				
2008	248	5400	4068	341
2010	329	5209	4205	200
2011	218	5875	4760	262
2012	390	6491	4436	535

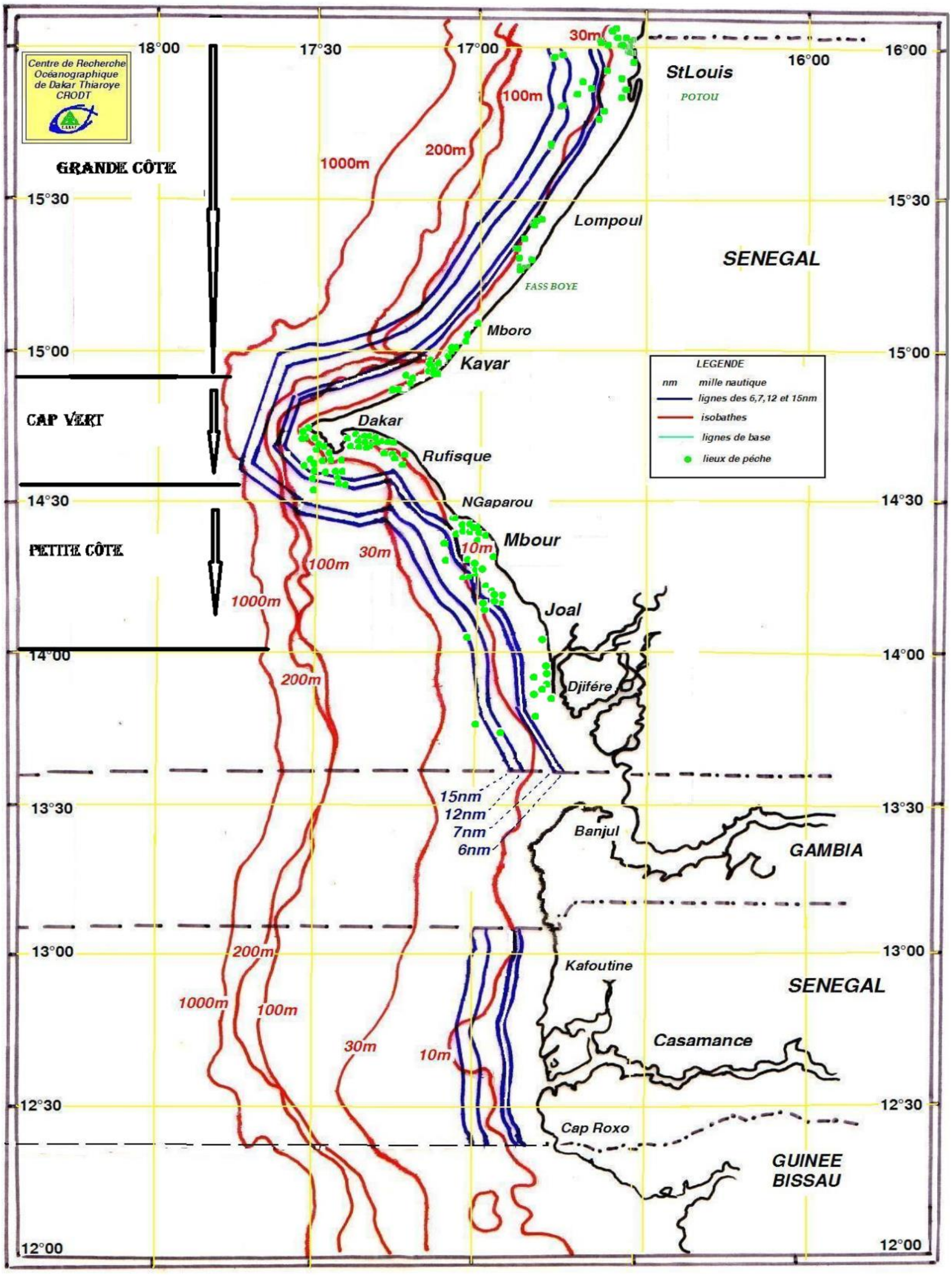


Figure 1. Localisation des lieux de pêche de la pêche artisanale sénégalaise présentés dans ce rapport.

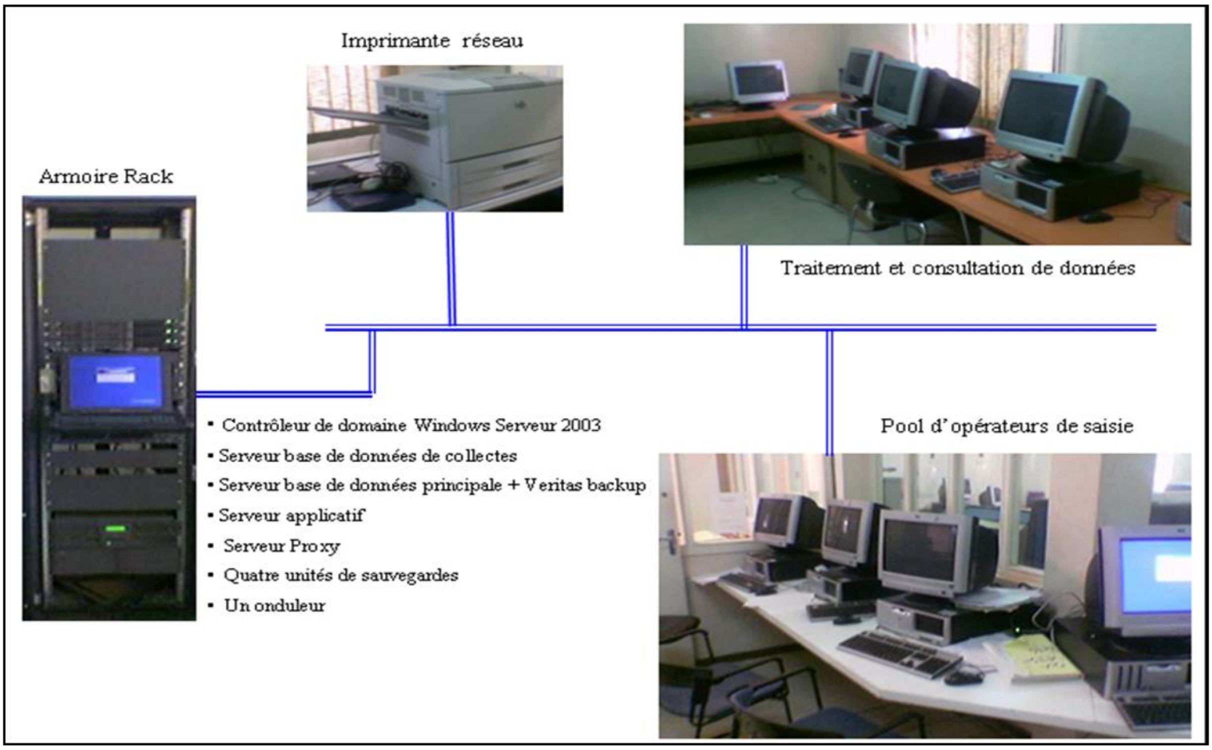


Figure 2 . Infrastructures de saisie et de gestion des données.

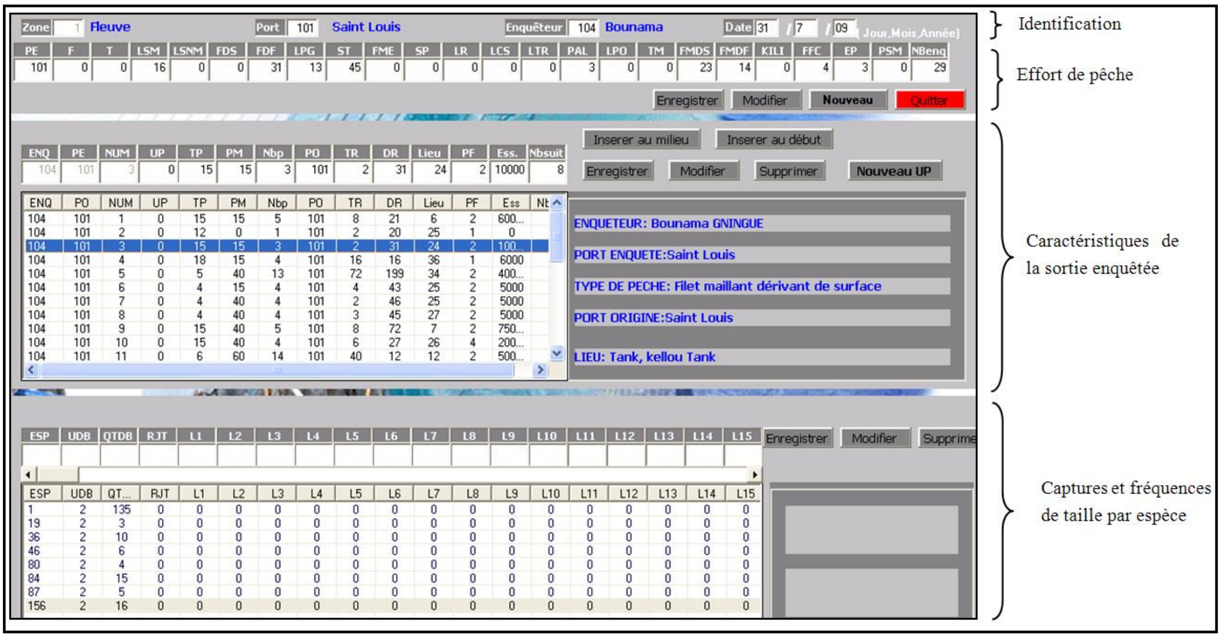


Figure 3 . Interface de saisie des données d'enquête de la pêche artisanale.

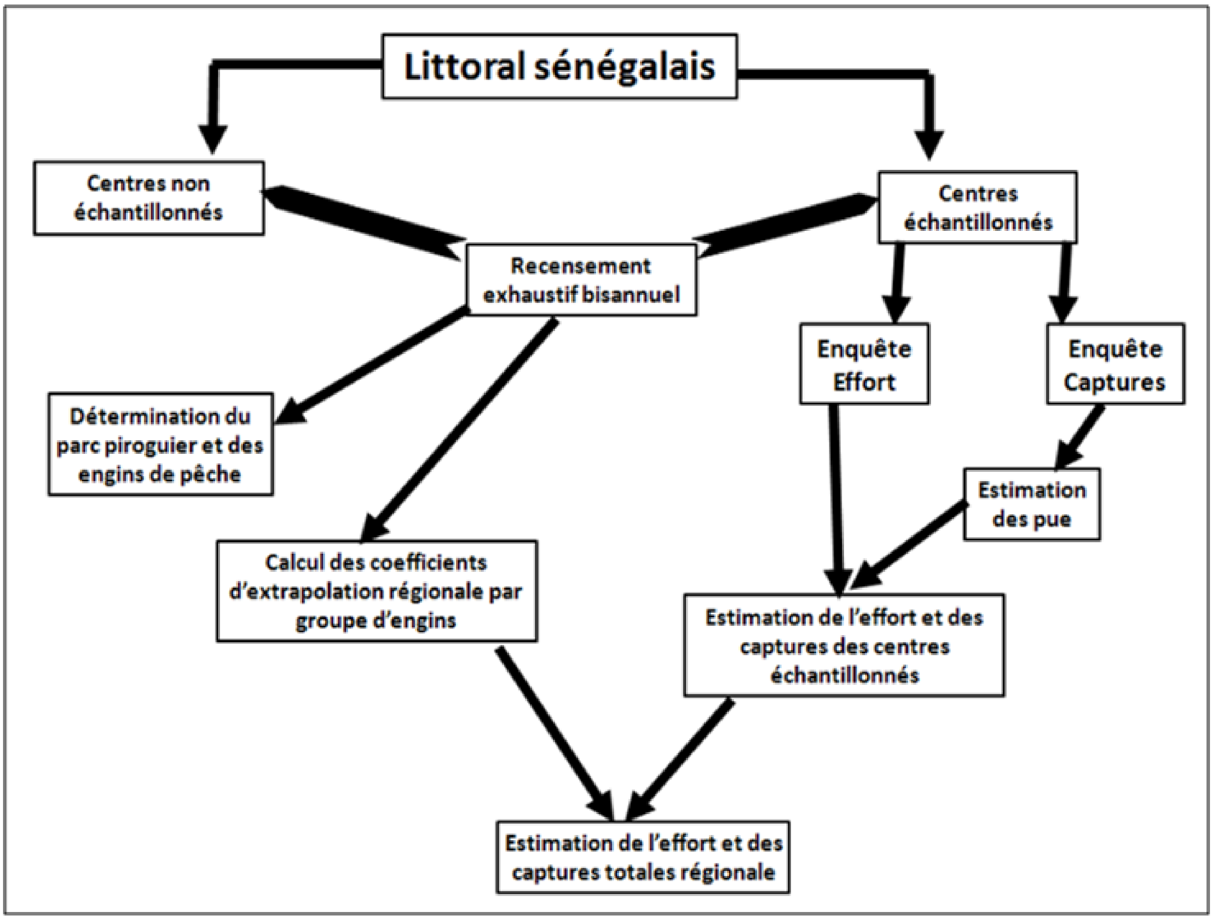


Figure 4 . Processus d'estimation des statistiques de pèche artisanale.

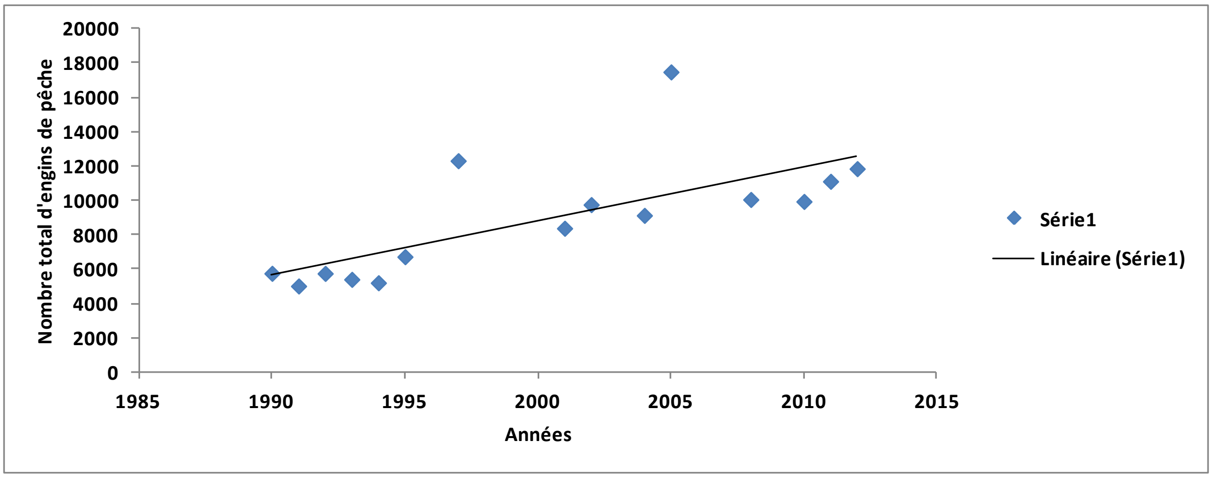


Figure 5 . Evolution du nombre total des principaux engins de pêche artisanale qui capturent les thons mineurs de 1990 à 2012.

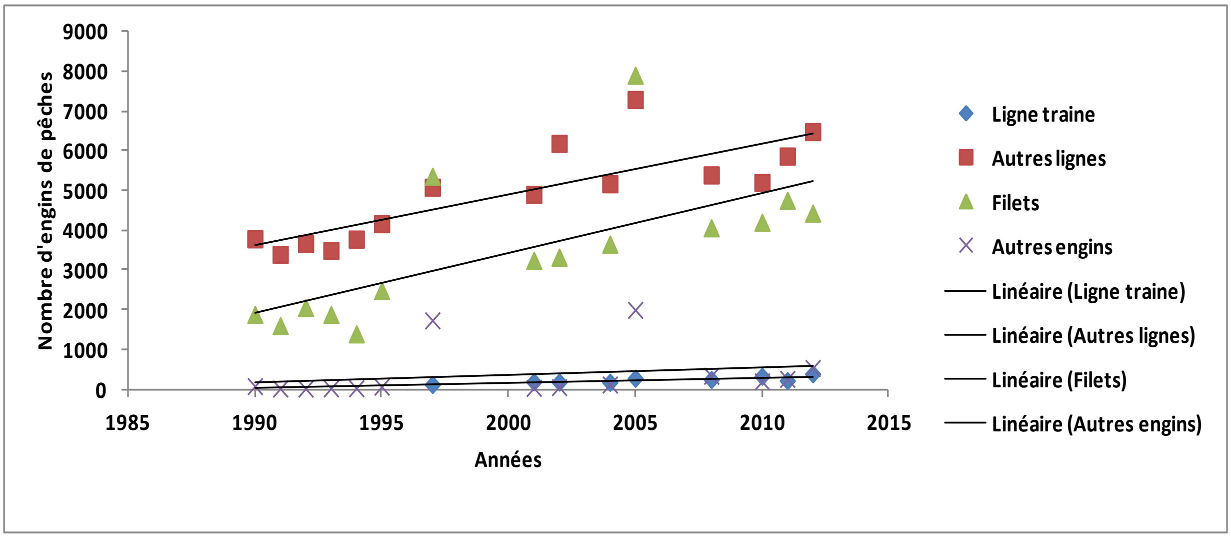


Figure 6 . Evolution du nombre par type engin engins de pêche artisanale qui capturent les thons mineurs de 1990 à 2012.

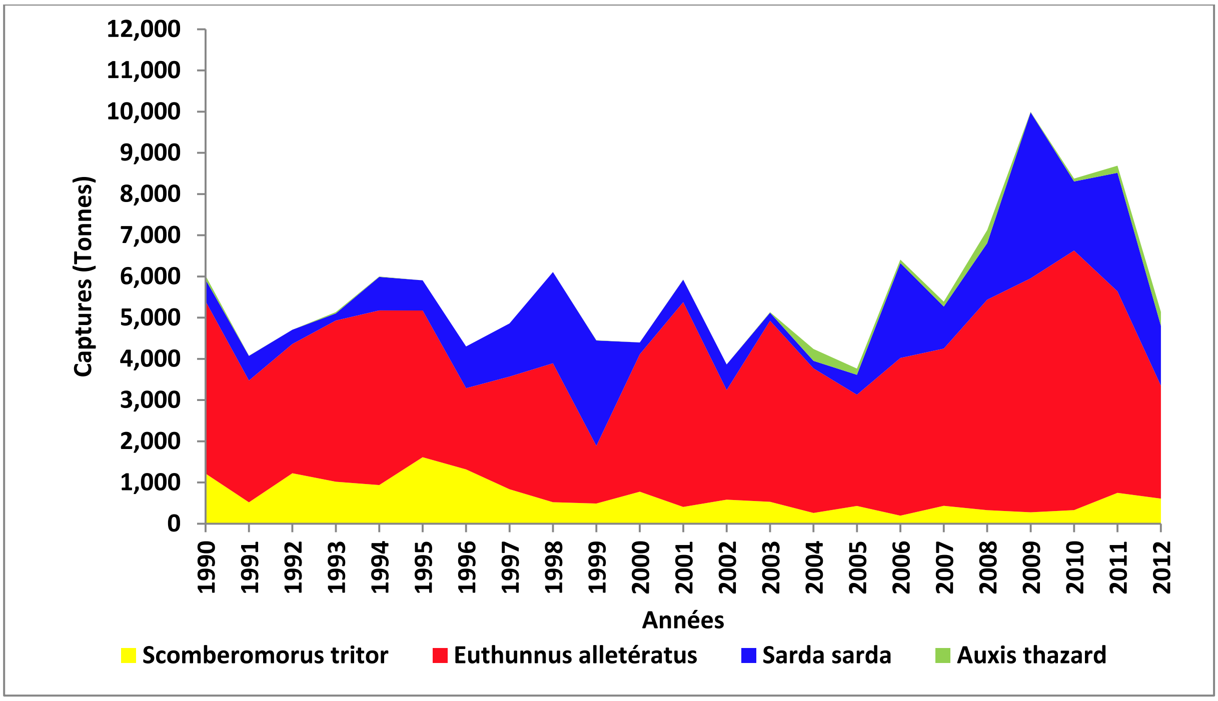


Figure 7 . Evolution des captures par espèce de 1990 à 2012.

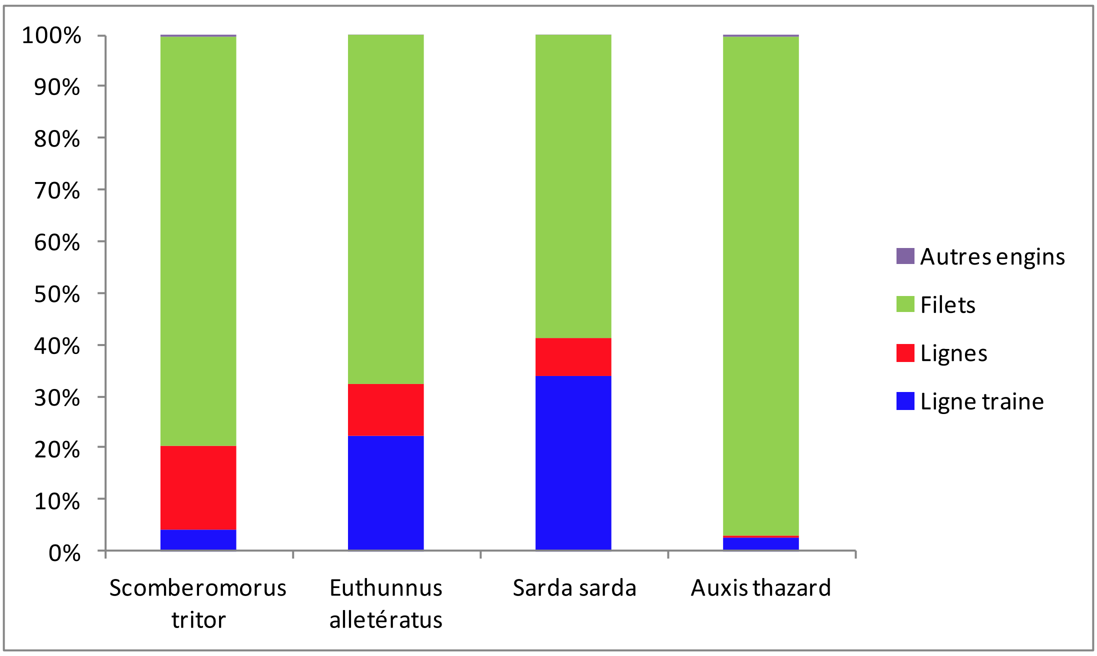


Figure 8 . Répartition des captures par espèce et type d'engins de pêche sur la période 1990-2012.

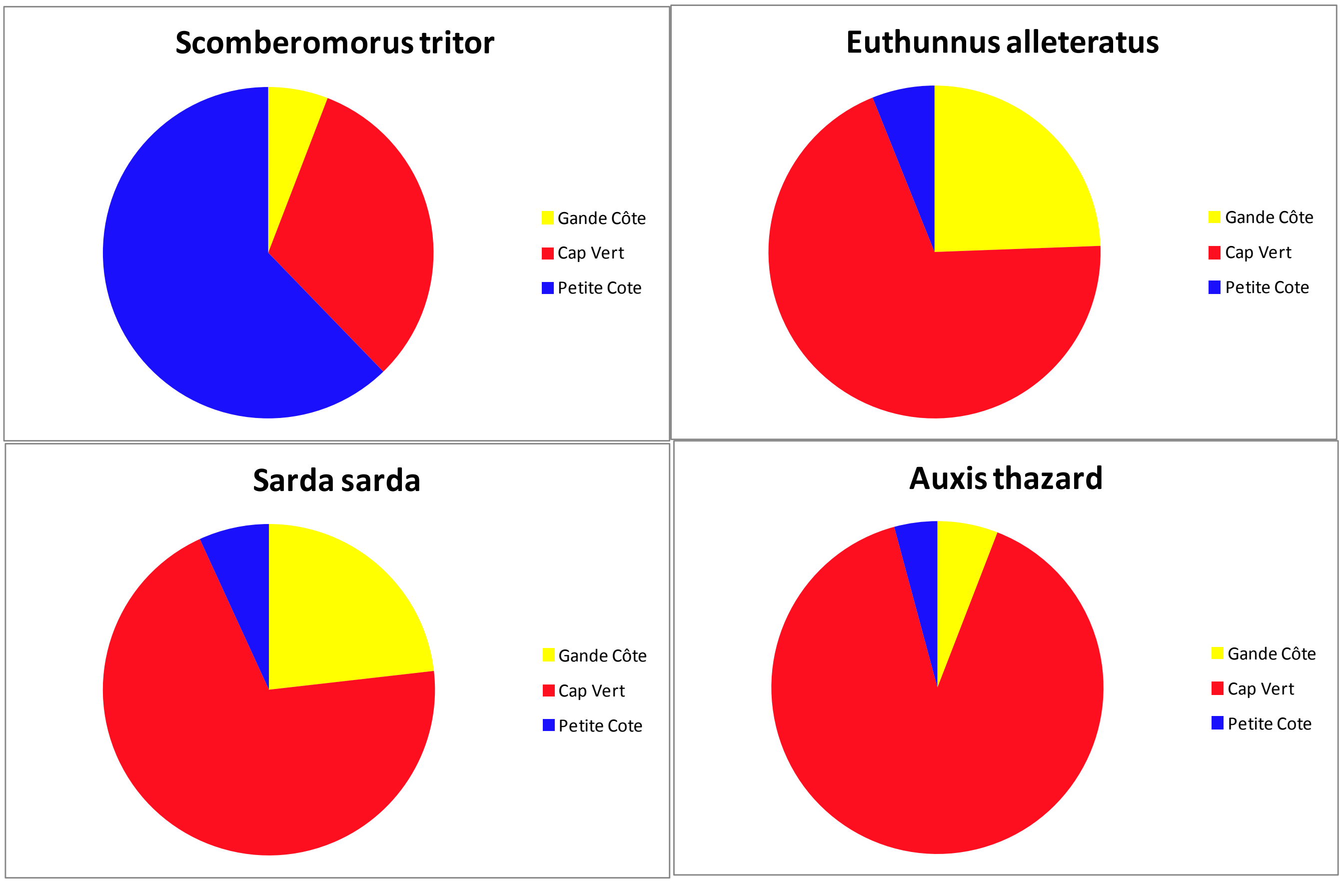
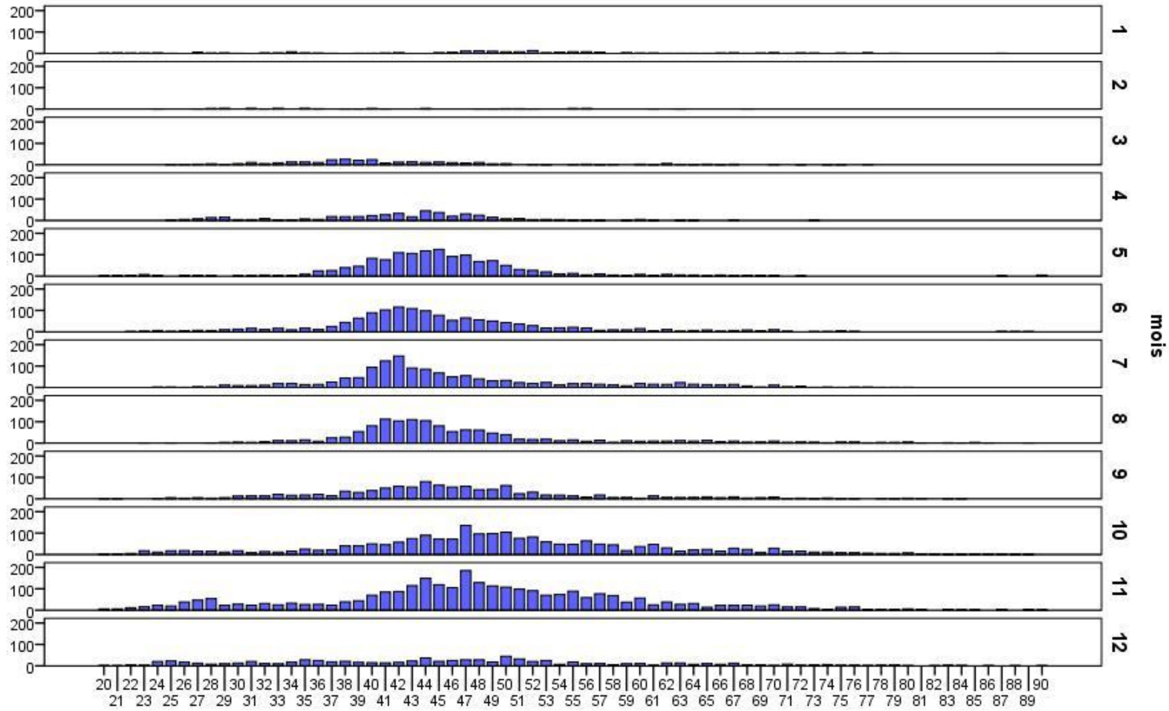
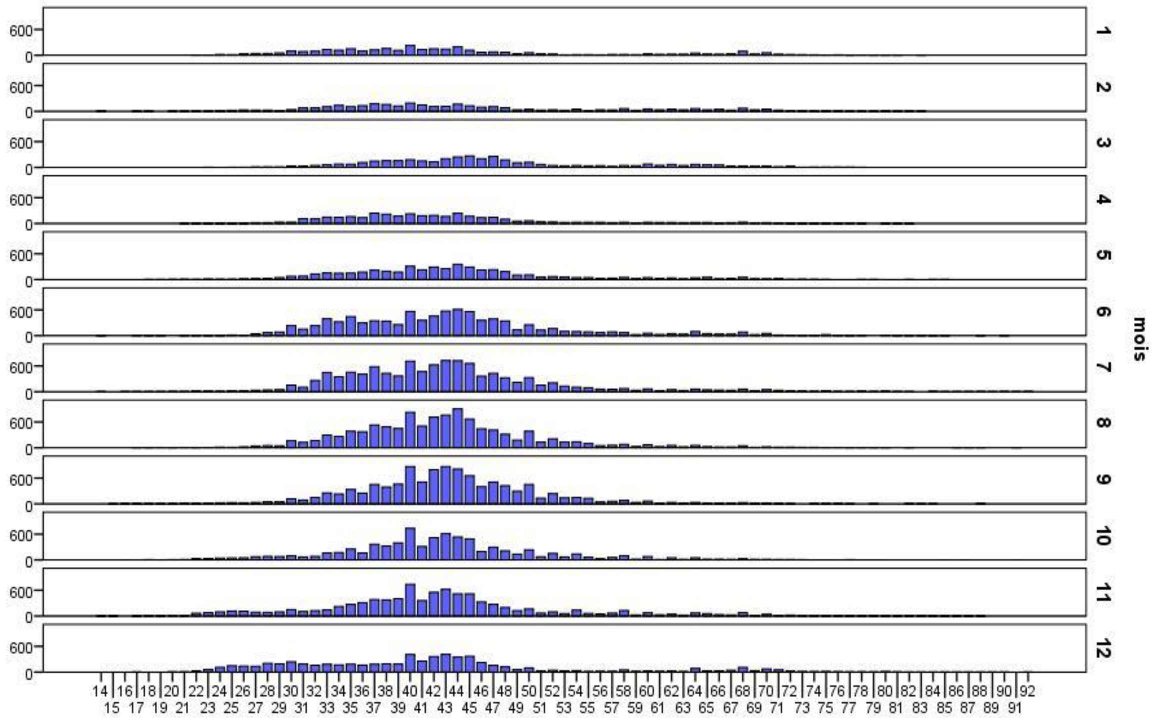


Figure 9 . Répartition des captures de la pêche artisanale par espèce et par Zone.

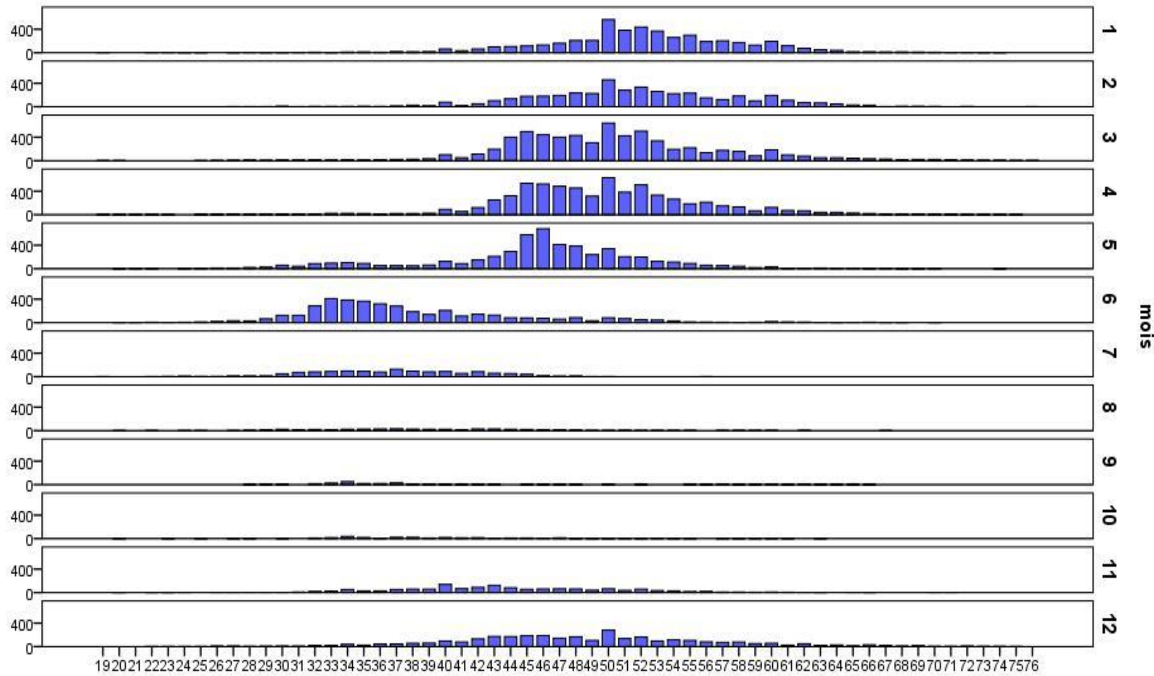


Scomberomerus tritor

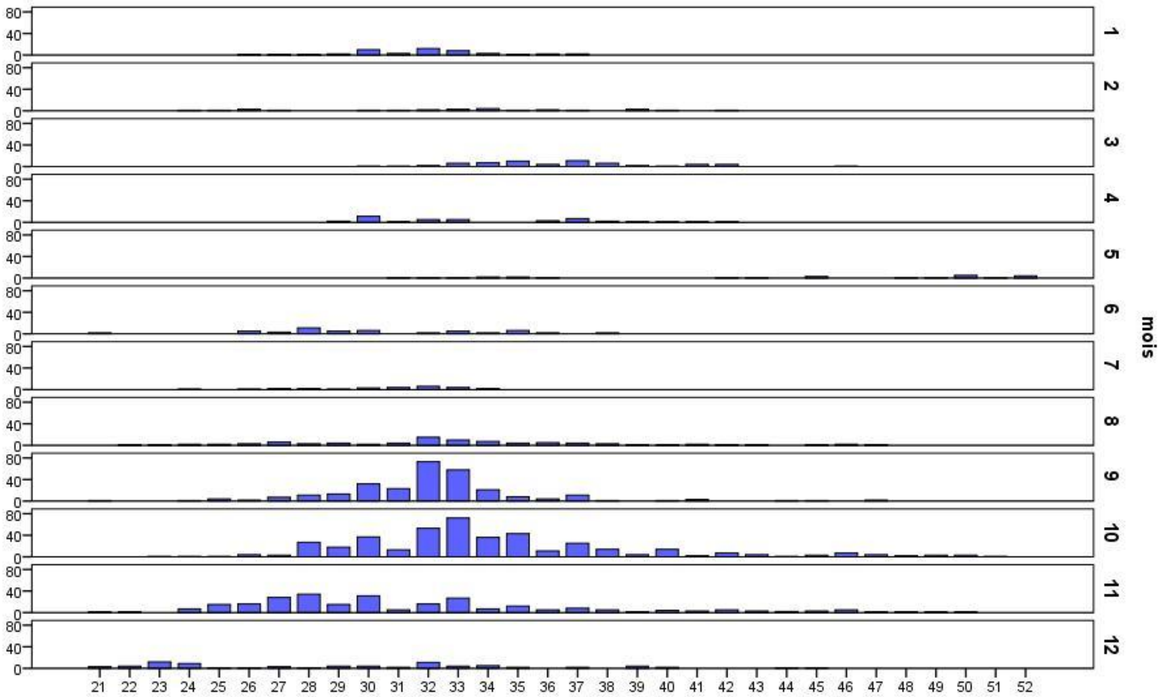


Euthynnus alletteratus

Figure 10 . Distribution des tailles tous engins confondus par mois MAW et LTA de 1990 à 2012.



Sarda Sarda



Auxide thazard

Figure 11 . Distribution des tailles tous engins confondus par mois de BON de 1990 à 2012 et FRI de 2004 à 2012.

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ANALYSE PRELIMINAIRE DES DONNÉES DE DEBARQUEMENTS DES THONS MINEURS EN TUNISIE

Rafik Zarrad[1]

SUMMARY

In this work we present the preliminary results of the data analyses of the small tuna landing in Tunisia. The mean annual landing (1995-2010) of these groups is 2,813 tons. The main port is Teboulba (Centre Tunisia/Ionian Sea) with a proportion of 32 %. In the second range come the ports of Mahdia, Sidi Daouad, Sfax and Kelibia with proportions between 7 and 10% each one. The main species are bullet tuna, Atlantic bonito (38.9%), skipjack (33.0%) and Atlantic black skipjack (27.1%). Monthly evolution of landing shows the seasonality of the activity. Indeed; the peaks are recorded by the end of spring, begin of summer.

RÉSUMÉ

Dans ce travail, nous présentons des résultats préliminaires d'analyses des données des débarquements des thons mineurs en Tunisie. La moyenne des débarquements annuels de ces espèces (1995-2010) est de l'ordre de 2.813 tonnes. Les principaux débarquements sont enregistrés dans le port de Teboulba avec une proportion voisine de 1/3. Les ports de Mahdia, Sidi Daouad, Sfax et Kelibia ont eu des pourcentages entre 7 et 10% chacun. Les principales espèces sont la bonite (38,9%), la pélamide (33,0%) et la thonine (27,1%) Pour l'évolution mensuelle des débarquements, nous notons la saisonnalité de l'activité. En effet, les pics s'enregistrent en mai et juin (fin du printemps début de l'été).

RESUMEN

En este documento se presentan los resultados preliminares de los análisis de datos de los desembarques de pequeños túnidos en Túnez. Los desembarques medios anuales (1995-2010) de este grupo de especies se sitúan en 2.813 t. El principal puerto es Teboulba (centro de Túnez/mar Jónico), con una proporción del 32%. En segundo lugar están los puertos de Mhadia, Sidi Daouad, Sfax y Kelibia, con proporciones entre el 7 y 10% cada uno. Las principales especies son melvera, bonito (38,9%), listado (33,0%) y bacoreta (27,1%). La evolución mensual de los desembarques muestra la estacionalidad de la actividad. De hecho, los puntos máximos se registran al final de la primavera y comienzo del verano.

KEYWORDS

Auxis rochei, *Fish larvae, Environmental conditions, East Tunisia, Mediterranean Sea*

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1. Introduction

Les thons mineurs représentent une ressource importante dans les pêcheries tunisiennes. Pour une meilleure gestion et une exploitation durable, il est nécessaire de bien étudier les espèces. Les études d'aménagements nécessitent en première étape la collecte des données statistiques des débarquements. En effet, l'objectif de ce travail est de connaitre la taille des débarquements annuels, les principales espèces et les principaux ports. Aussi en vise de savoir la période de maximums des débarquements.

2. Matériel and méthodes

Les données historiques des débarquements des thons mineurs en Tunisie sont collectées au près de la Direction Générale de la Pêche et de l'Aquaculture (DGPA-Ministère de l'Agriculture) (DGPA 2011). Ces données sont de 1995 à 2010, par espèce, par port et par mois. Elles sont sous format électronique.

3. Résultats et discussions

La moyenne des débarquements de ces espèces (1995-2010) et de l'ordre de 2813 tonnes. L'évolution annuelle des débarquements montre que les maxima ont été enregistrés en 2000 et 2010, avec des quantités de l'ordre de 3500 tonnes (**Figure 1**). Au niveau spécifique nous notons des grandes variations (**Figure 2**), avec une tendance d'augmentation pour la pélamide.

Les principales espèces sont la bonite (38,9%), la pélamide (33,0%) et la thonine (27,1%) (**Figure 3**) avec des variations annuelles (**Figure 4**).

Pour l'évolution mensuelle des débarquements, nous notons la saisonnalité de l'activité (**Figures 5 et 6**). En effet, les pics s'enregistrent en mai et juin (fin du printemps début de l'été).

Les principaux débarquements des thons mineurs en Tunisie, sont enregistrés dans le port de Teboulba avec une proportion voisine de 1/3 (**Figure 7**). En second ordre d'importance, les ports de Mahdia, Sidi Daouad, Sfax et Kelibia ont eu des pourcentages entre 7 et 10% chacun.

4. Conclusion

Les débarquements moyens des thons mineurs de la Tunisie sont de l'ordre de 2813 tonnes. Le principal port c'est celui de Teboulba avec une proportion de l'ordre de 1/3. Les navires de ce port sont actifs dans la mer ionienne. La période principale de pêche de ces espèces est les mois mai et juin.

Références

D.G.P.A. (Direction Générale de la Pêche et de l'Aquaculture), 2011. Annuaires des Statistiques des Produits de la Pêche en Tunisie.

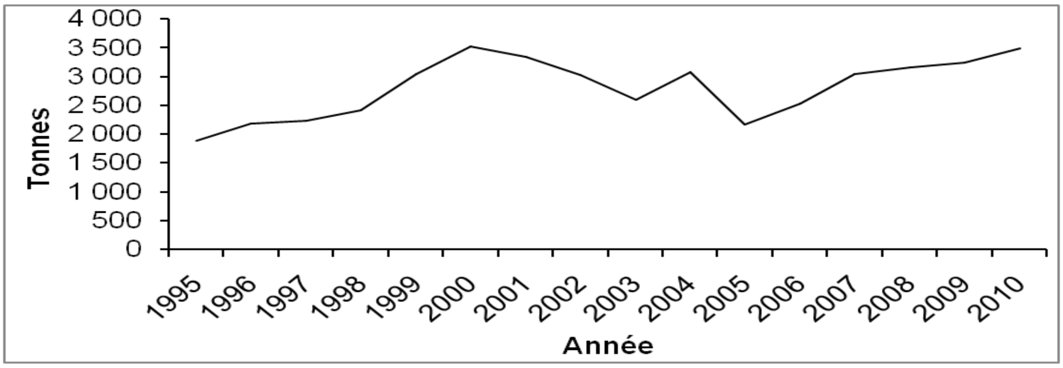

Figure 1. Evolution annuelle des débarquements totaux des thons mineurs en Tunisie (1995-2010).

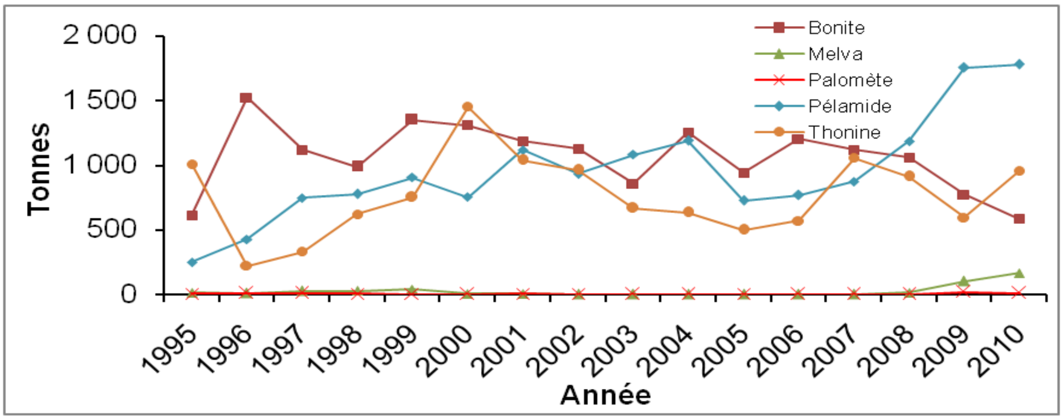

Figure 2. Evolution annuelle des débarquements spécifiques des thons mineurs en Tunisie (1995-2010).

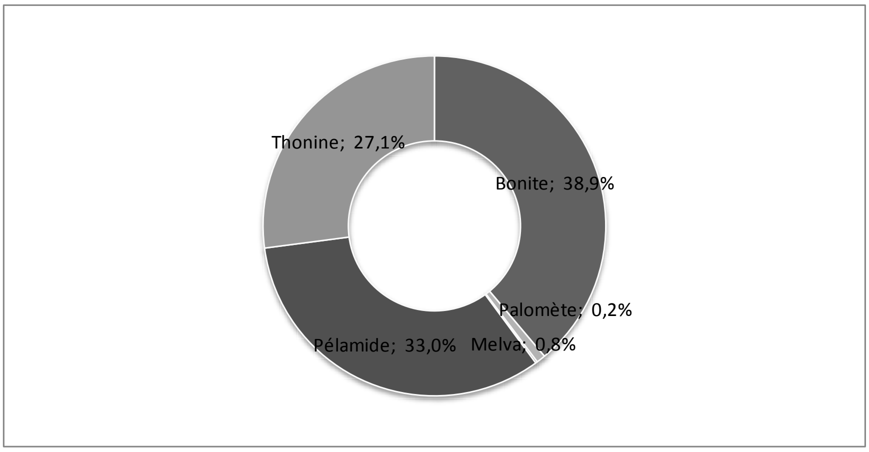

Figure 3. Composition spécifique des débarquements des thons mineurs en Tunisie (Moyenne 1995-2010).

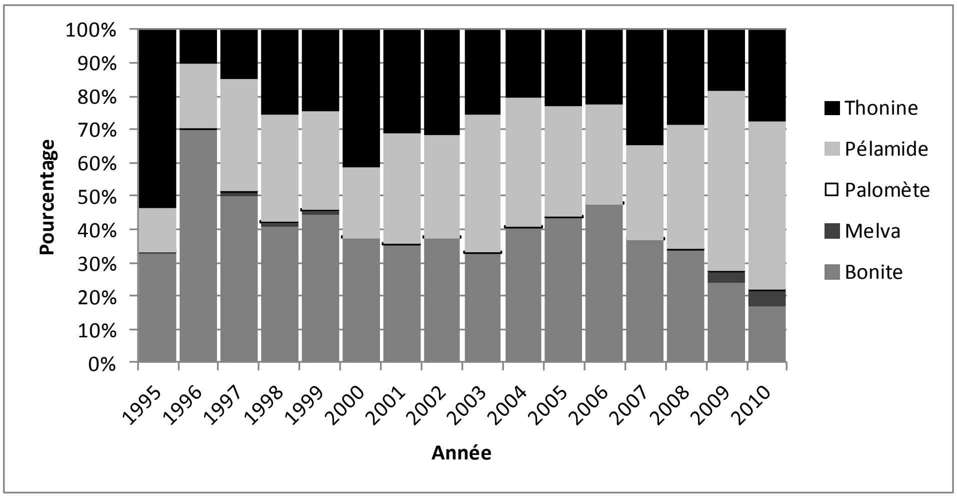

Figure 4. Composition spécifique des débarquements des thons mineurs en Tunisie (Moyenne 1995-2010).

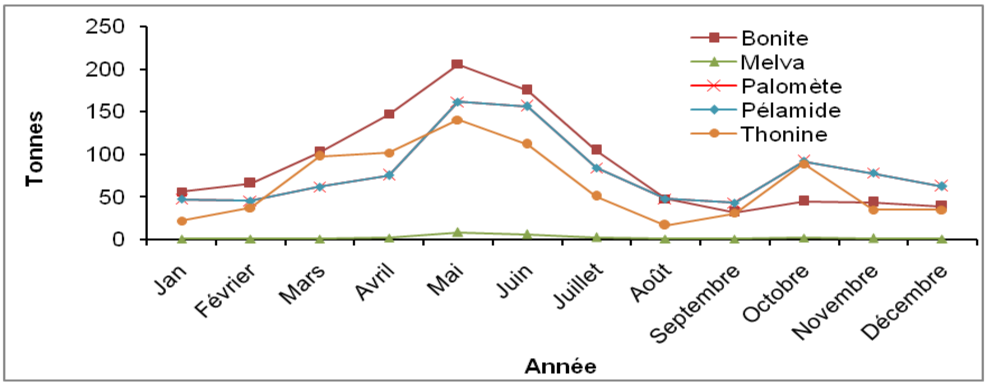

Figure 5. Evolution mensuelle des débarquements des thons mineurs en Tunisie (moyenne 1995-2010).

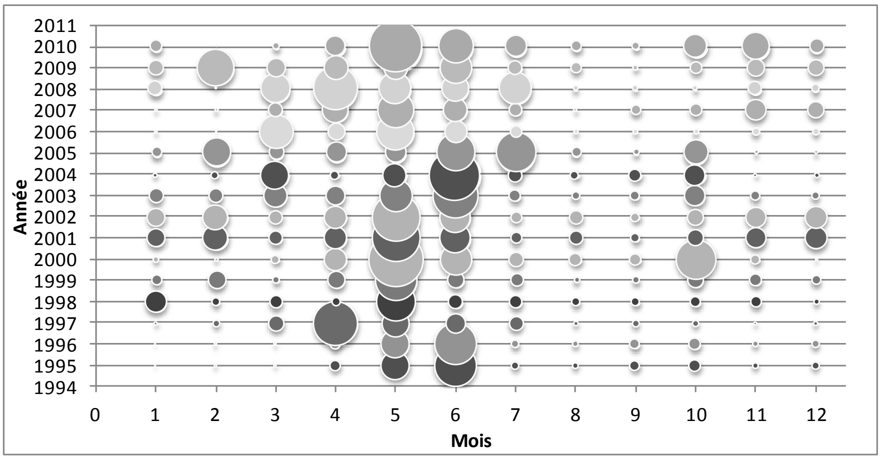

Figure 6. Dimension des débarquements mensuels des thons mineurs en Tunisie (1995-2010).

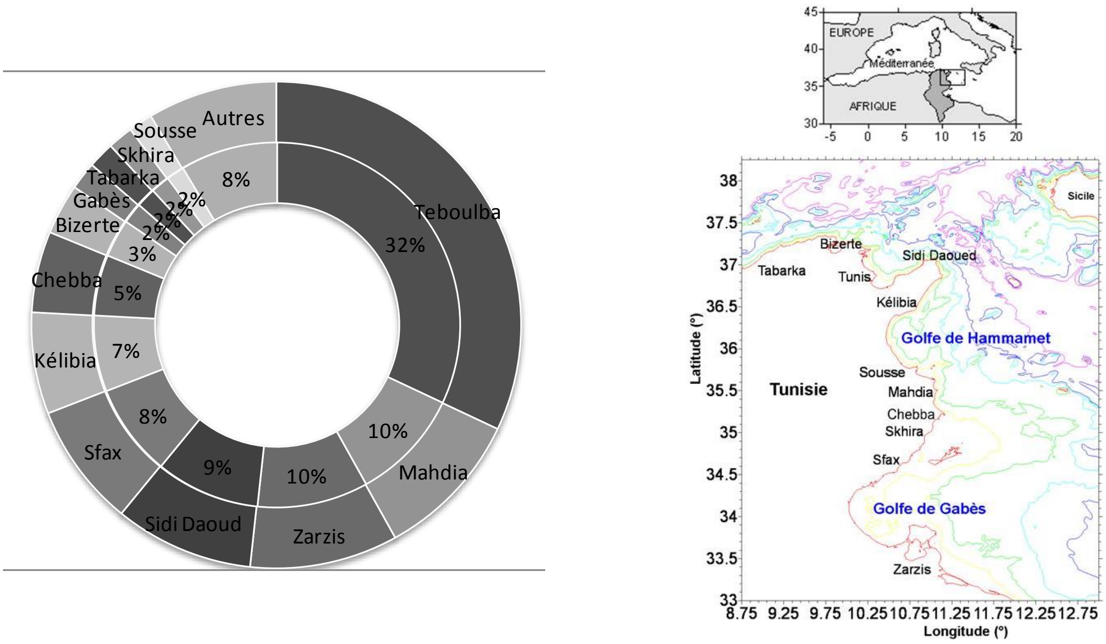

Figure 7. Principaux ports débarquant les thons mineurs en Tunisie.

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DESCRIPTION DE L'ACTIVITE DES PALANGRIERS CIBLANT LES THONIDES MINEURS AU NIVEAU DU PORT DE LAAYOUNE DURANT LA PERIODE 2008-2012

S. A. Baibbat[1], N. Abid[2]

SUMMARY

Tuna fisheries occupy a very important place in the Laayoune region, with an average production of 677,89 t. The activity of vessels targeting these species and operating from the port of Laayoune, was analysed for the 2008-2012 period. The highest amounts of small tuna catches are recorded generally between April and December. The level of catches is strongly linked to the fishing effort.

RÉSUMÉ

La pêcherie des thonidés occupe une place primordiale dans la région de Laayoune, avec une production moyenne de 677.89 t. L'activité des bateaux ciblant ces espèces et opérant à partir du port de Laayoune, a été analysée durant la période 2008-2012. Les plus fortes prises des thonidés mineurs sont enregistrées généralement entre avril et décembre. Le niveau de capture est fortement lié à l'effort de pêche.

RESUMEN

La pesquería de túnidos ocupa un lugar principal en la región de Laayoune, con una producción media de 677,89 t. Se ha analizado la actividad de los buques que se dirigen a estas especies y operaron desde el puerto de Laayoune durante el periodo 2008-2012. Las capturas más elevadas de pequeños túnidos se realizan generalmente entre abril y diciembre. El nivel de captura está muy relacionado con el esfuerzo pesquero.

KEYWORDS

Thonidés mineurs, Effort de pêche, Capture, CPUE

1. Introduction

Le Maroc occupe une position géographique particulière. Il possède une double façade maritime : l'océan Atlantique et la mer Méditerranée, son littoral s'étend à environ 3.500km. La présence du phénomène d'upwelling, offre au pays un véritable potentiel de production des ressources halieutiques y compris les thonidés mineurs (*sarda sarda, Katsuwonus pelamis, Orcynopsis unicolor…).*

Ces espèces, ont une très grande importance sur le plan écologique qu'économique, aussi bien à l'échelle nationale ou régionale qu'internationale. Au niveau du port de Laayoune ces espèces sont exploitées essentiellement par des unités côtières et les débarquements se font au niveau de la halle de Laayoune.

La pêche au thonidés mineurs, est caractérisée par son caractère multi-engins et une saisonnalité très marquée dans l'utilisation de ces engins. La flotte palangrière est caractérisée par un mouvement permanent entre les différents ports de la région, ce mouvement est conditionné par la recherche des espèces cibles, par les conditions climatiques et par le niveau des prix accordés par les mareyeurs.

A cet effet, l'objectif de ce document est de faire une analyse de l'activité des palangriers exploitants les thonidés mineurs dans la région maritime de Laayoune (27°05'43.66 N et 13°25'45.79 O), située sur la côte atlantique sud Marocaine **(Figure 1)**.

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2. Matériel et méthodes

Les statistiques de pêche analysées dans cette étude pour la période 2008-2012 proviennent du système statistique national basé sur les ventes journalières enregistrées au niveau de l'office national des pêches dont les délégations régionales couvrent tout le littoral atlantique et méditerranéen marocain.

3. Résultats

3.1 Indicateurs de l'exploitation

3.2 L'effort de pêche

3.2.1 Nombre de bateaux actifs

Le nombre des bateaux actifs ciblant les thonidés mineurs à partir du port de Laayoune, connait des fluctuations d'une année à l'autre. En 2012 le nombre de ces bateaux a atteint 96 unités, avec un maximum de 184 en 2010 **(Figure 2).**

L'évolution mensuelle du nombre de bateaux montre une intense activité entre Avril et Décembre **(Figure 3).**

3.2.2 Nombre de sorties

Le nombre de sorties a augmenté de 2008 à 2010 pour passer de 116 à 143, ensuite il a connu une chute d'environ 59% en 2011 pour augmenter par la suite en 2012 avec 137 sorties effectuées **(Figure 4).**

L'évolution mensuelle du nombre des sorties au niveau du port de Laayoune enregistre des fluctuations d'un mois à l'autre **(Figure 5).** D'une façon générale le nombre de sorties est lié au nombre de bateaux actifs.

L'activité est intense durant la période avril-décembre. La faible activité des bateaux en février peut être expliqué surtout par les conditions climatiques défavorables en cette période pour les sorties en mer.

4. Production

L'évolution des captures des thonidés mineurs, au port de Laayoune entre 2008 et 2012 présente un minimum en 2010 (523.63T) et un maximum enregistré en 2012 (878.07T), avec une capture moyenne de 677.89T **(Figure 6).**

L'espèce dominante est la bonite à dos rayé (*Sarda sarda)* (1373 T), qui présente environ 42% des prises débarquée durant la période 2008-2012, suivi par l'auxide (*Auxis thazard),* le lisato *(Katsuwonus pelami)s* et la palomette *(Orcynopsis unicolor),* avec respectivement 848 T, 627 T, 477 T **(Figure 7).**

L'évolution mensuelle des captures, est similaire à celle de l'effort de pêche avec un maximum enregistré entre avril et décembre **(Figure 8).** Le niveau de capture des thonidés mineurs est donc fortement lié à celui de l'effort de pêche.

5. Capture par unité d'effort (CPUE)

La CPUE des unités côtières, débarquant les thonidés mineurs durant la période 2008-2012, ne montre pas une tendance claire. Elle a enregistré un maximum de 9.01T par sortie en 2011 et un minimum de 3.74T par sortie en 2010 **(Figure 9).**

6. Distribution des fréquences de taille

Les données présentées dans ce document concernent la bonite à dos rayé échantillonné au port de laayoune en 2012. La distribution des fréquences de taille de cette espèce, montre une structure démographique couvrant pas mal de tailles.

Cette structure est dominée par les tailles comprise entre 44cm et 66cm, avec deux classes modales 48-49 cm et 50-51 cm qui représente 46% de l'effectif total **(Figure 10)**.

Les fréquences de tailles mensuelles pendant l'année 2012 montre une dominance des tailles comprise entre 48cm et 51cm, sauf en septembre et octobre ou apparait un pic à la taille 56 cm et 57 cm **(Figure 11)**.

7. Conclusion

Au port de Laayoune, les thonidés mineurs sont exploités essentiellement par des unités côtières, avec 619 sorties réalisés durant la période 2008-2012.

Les fluctuations de l'effort de pêche peuvent être expliquées par les migrations des bateaux vers d'autre port de la région.

Le niveau des captures de ces espèces au niveau de la région de Laayoune, est fortement lié avec celui de l'effort de pêche.

Les structures de tailles montrent deux classes modales (48-49 cm et 50-51 cm).

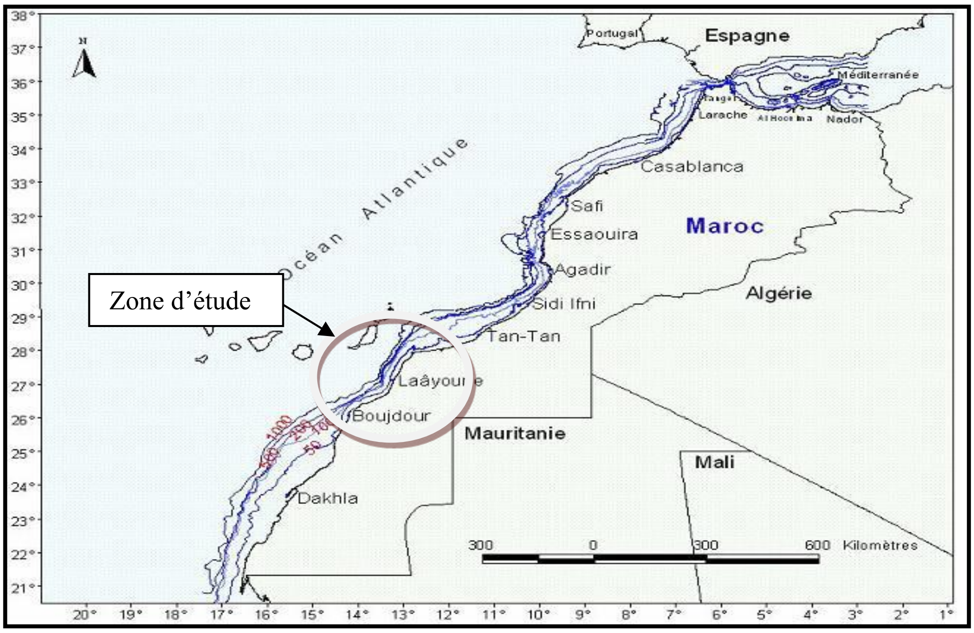

Figure 1. Situation géographique de la zone d'étude

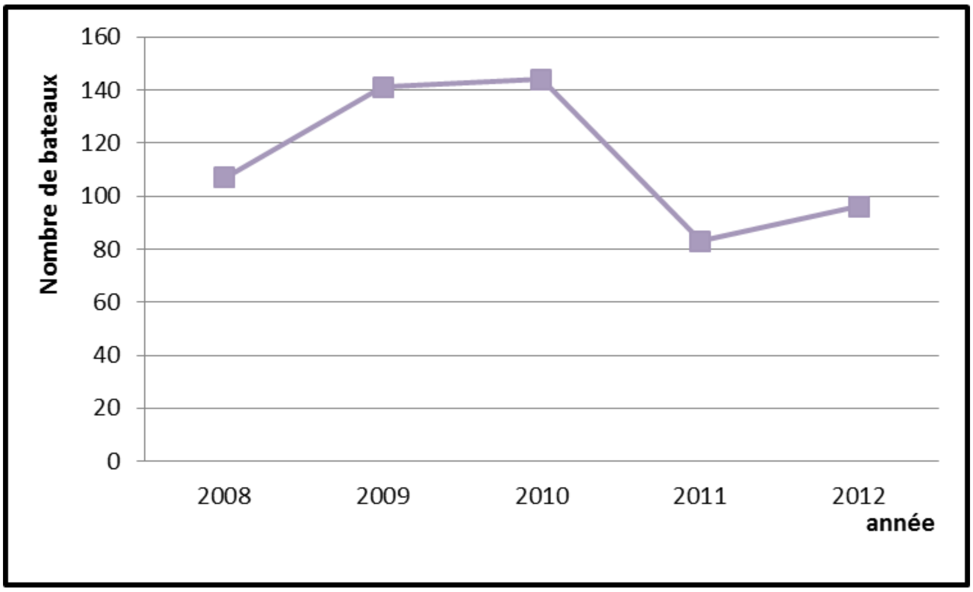

Figure 2. Evolution annuelle du nombre de bateaux ciblant les Thonidés mineurs au port de Laayoune durant la période 2008-2012.

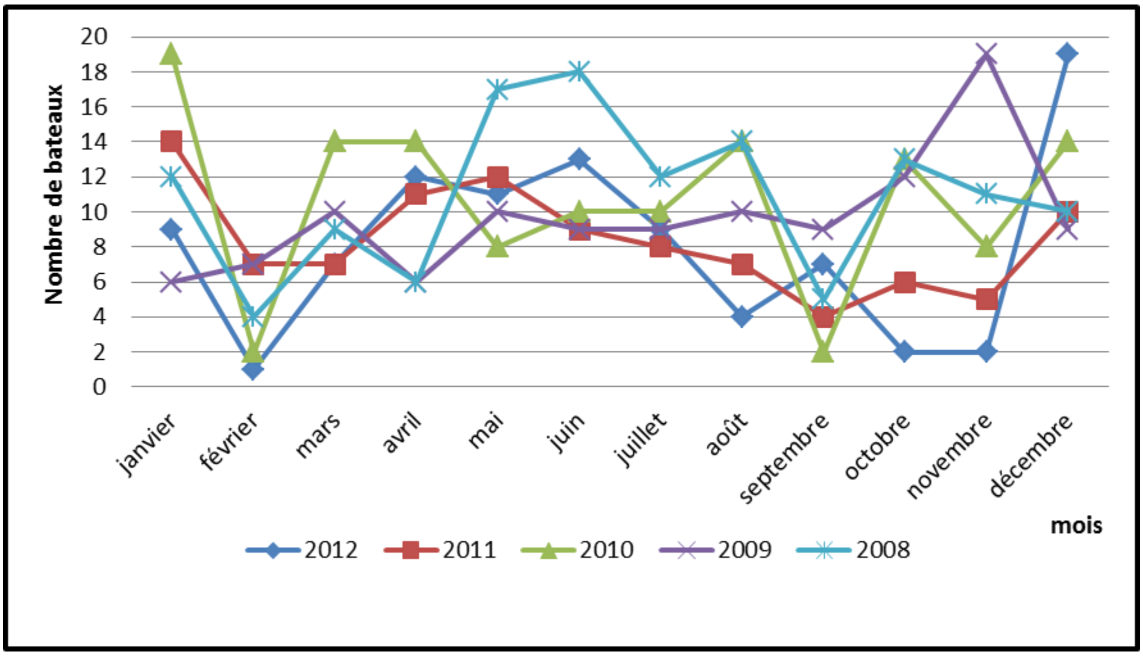

Figure 3. Evolution mensuelle du nombre de bateaux ciblant les Thonidés mineurs au port de Laayoune durant la période 2008-2012

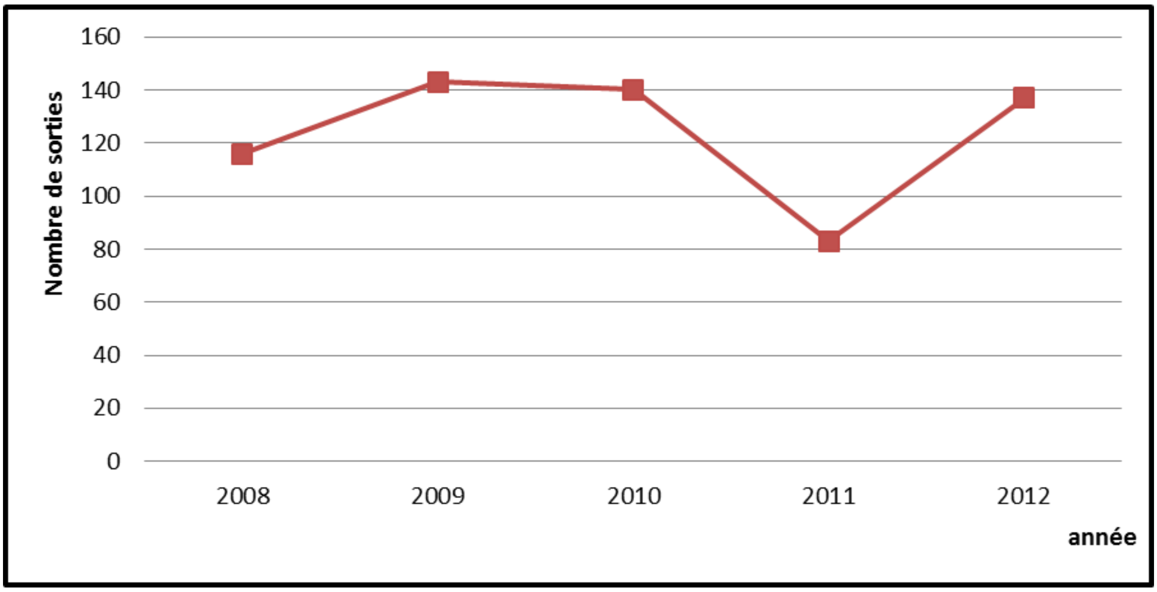

Figure 4. Evolution annuelle du nombre de sorties au port de Laayoune durant la période 2008-2012.

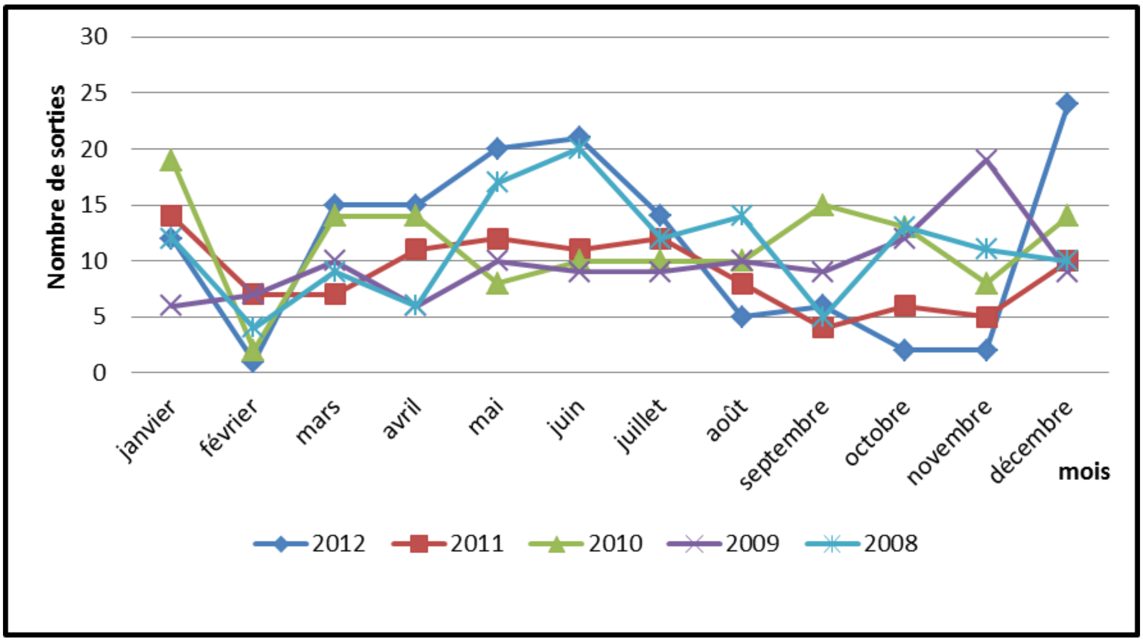

Figure 5. Evolution mensuelle du nombre de sorties au port de Laayoune durant la période 2008-2012.

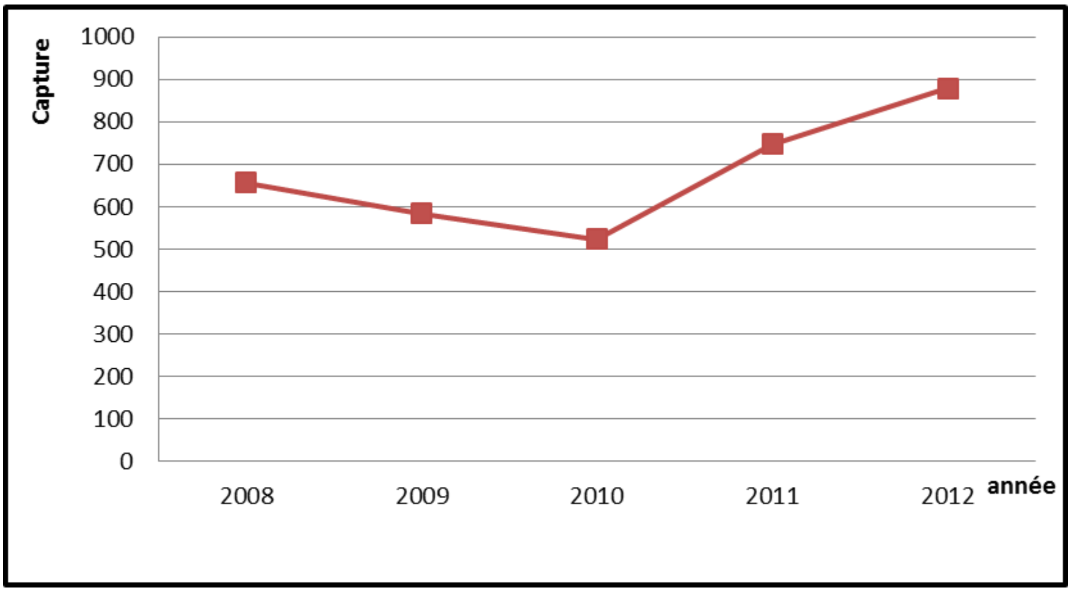

Figure 6. Evolution annuelle des captures des thonidés mineurs débarqués au port de Laayoune durant la période 2008-2012.

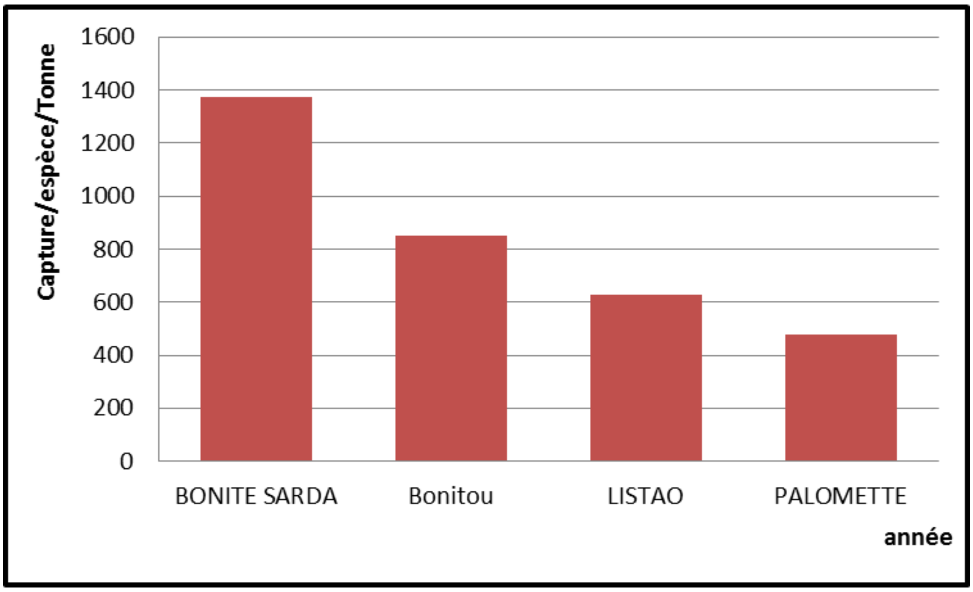

Figure 7. Evolution des thonidés mineurs débarqués au port de Laayoune durant la période 2008-2012.

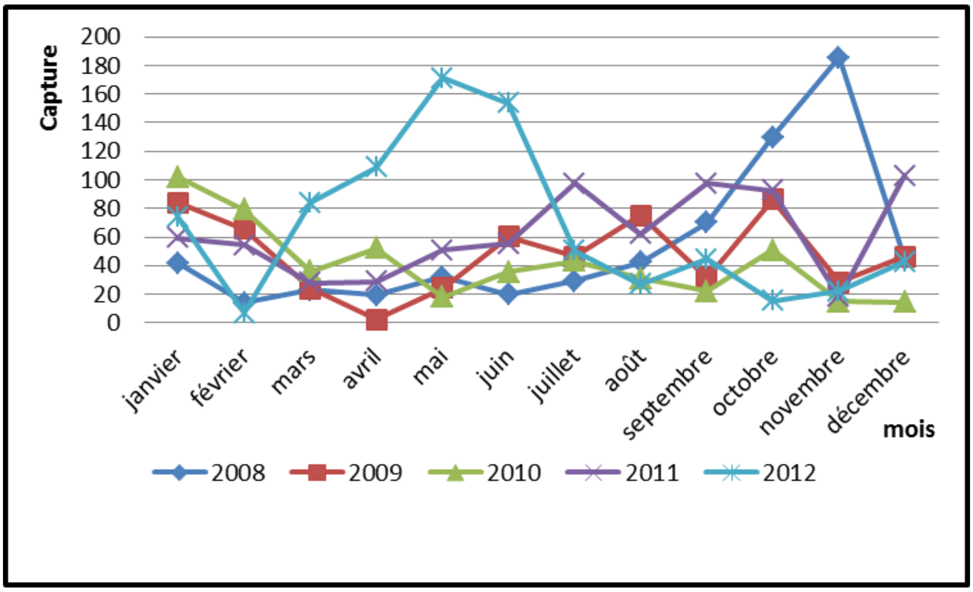

Figure 8. Evolution mensuelle des captures des thonidés mineurs débarqués au port de Laayoune durant la période 2008-2012.

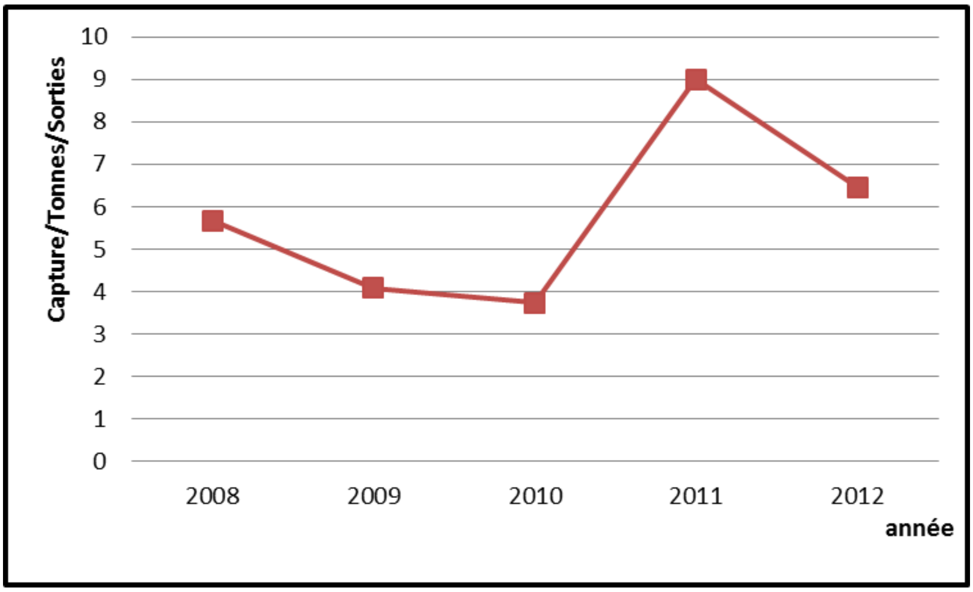

Figure 9. Evolution annuelle du rendement des palangriers ciblant les thonidés mineurs au port de Laayoune durant la période 2008-2012.

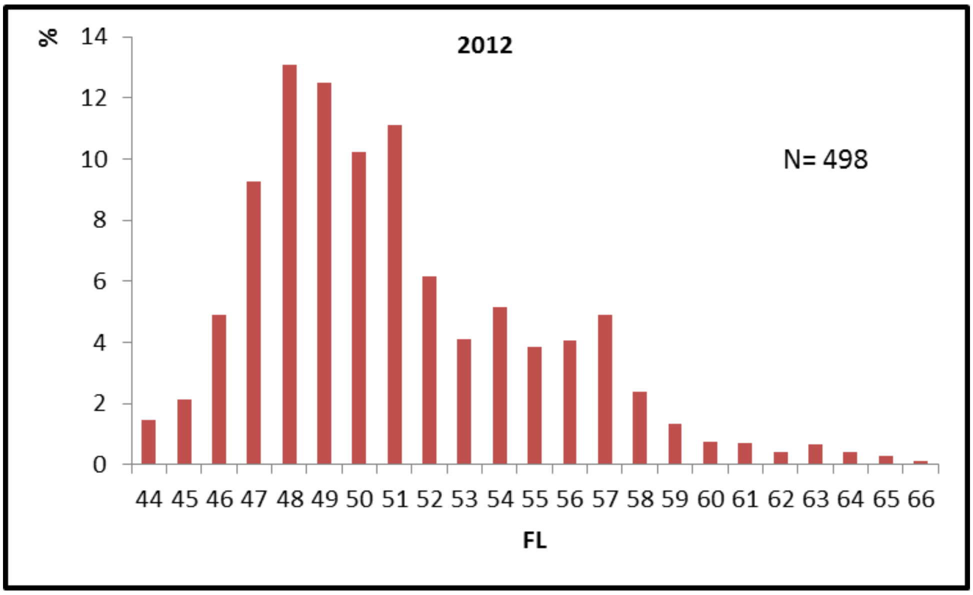

Figure 10. Structure annuelle de tailles de la bonite à dos rayé de l'année 2012.

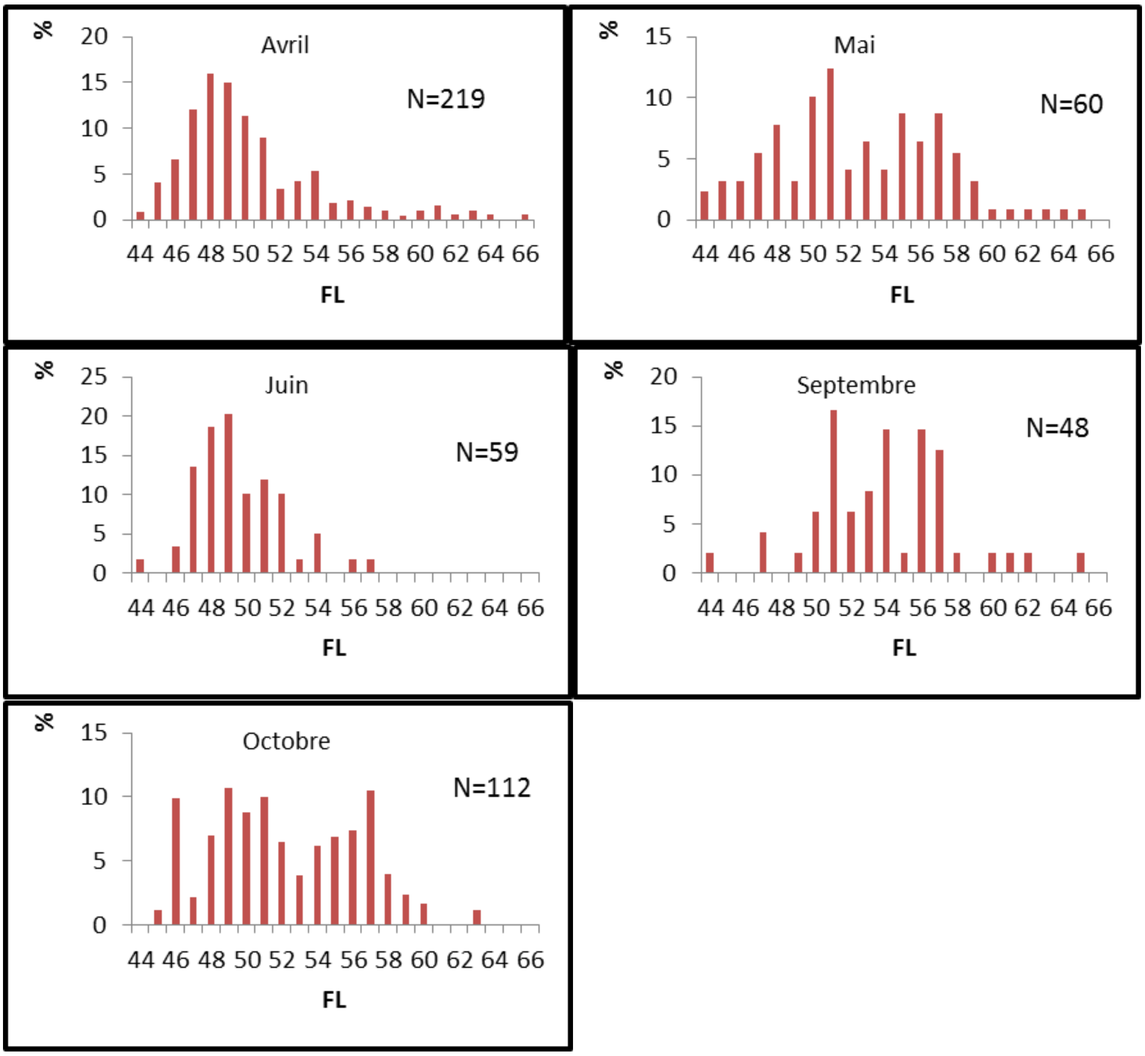

Figure 11. Structure mensuelle de taille de la bonite à dos rayé de l'année 2012.

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ANALYSIS OF STOMACH CONTENTS OF DOLPHINFISH, *CORYPHAENA HIPPURUS*, LINNAEUS, 1758 (ACTINOPTERYGII, CORYPHAENIDAE), OFF THE NORTHERN COAST OF RIO DE JANEIRO STATE, BRAZIL

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Lucas Aguiar Marques[2]; Thiago Xavier Gomes[2]; Alberto Ferreira de Amorim[3]

SUMMARY

The dolphinfish, Coryphaena hippurus*, is a pelagic species that occurs practically in all tropical and subtropical seas of the world. In the two last decades, a significant increase in its catch has been observed due to the use of different fishing gear mainly a multispecific small size fleet. In this study, 409 stomachs were sampled during the period from September 2003 to March 2009, off the northern coast of Rio de Janeiro State, Brazil (22ºS to 24ºS and 40°W to 44°W). The stomach contents were measured and a quantitative analysis was performed to identify the main, secondary and companions species using the method of Numerical Relative Frequency and Relative Abundance. We observed that 319 contained food (78.0%), 65 were empty (15.9%), 14 contained digested and unidentified fish bones digested (3.4%), six contained various plastic pieces (1.5%), four contained floating algae (1.0%) and one contained fishhook (0.2%). For a sustainable management of a fishery, the knowledge on the connection between trophic and food consumption rates of top predators is required to elucidate the importance of the main predators and fishers in the fishery.*

RÉSUMÉ

La coryphène commune (Coryphaena hippurus) est une espèce pélagique qui se trouve pratiquement dans toutes les mers tropicales et subtropicales du monde. Au cours des deux dernières décennies, on a observé une augmentation considérable de ses captures en raison de l'emploi d'un engin de pêche différent, essentiellement une flottille plurispécifique de petite taille. Dans la présente étude, 409 contenus stomacaux ont fait l'objet d'échantillonnage entre septembre 2003 et mars 2009, au large de la côte septentrionale de l'état de Rio de Janeiro, Brésil (22ºS à 24ºS et 40°W à 44°W). Les contenus stomacaux ont été mesurés et une analyse quantitative a été effectuée en vue d'identifier les espèces principales, secondaires et autres à l'aide de la méthode de la fréquence relative numérique et de l'abondance relative. Nous avons observé que 319 d'entre eux contenaient de la nourriture (78,0%), 65 étaient vides (15,9%), 14 contenaient des arêtes de poissons digérées et non-identifiées (3,4%), six contenaient divers morceaux de plastique (1,5%), quatre contenaient des algues flottantes et un contenait un hameçon (0,2%). Pour obtenir la gestion durable d'une pêcherie, il est nécessaire de connaître la connexion entre les niveaux trophiques et les taux de consommation de nourriture des prédateurs au sommet de la chaîne afin d'élucider l'importance des principaux prédateurs et pêcheurs dans la pêcherie.

RESUMEN

El dorado, Coryphaena hippurus*, es una especie pelágica que se encuentra prácticamente en todos los mares tropicales y subtropicales del mundo. En las dos últimas décadas, se ha observado un aumento significativo en la captura debido al uso de diferentes artes de pesca, principalmente a una flota multiespecífica de pequeño tamaño. En este estudio, se muestrearon 409 estómagos durante el periodo de septiembre de 2003 a marzo de 2009, en la costa norte del Estado de Río de Janeiro, Brasil (22ºS a 24ºS y 40°W a 44°W). Se midieron los contenidos estomacales y se realizó un análisis cuantitativo para identificar las principales especies, las secundarias y las complementarias, utilizando el método de frecuencia relativa numérica y de*

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abundancia relativa. Hemos observado que 319 contenían comida (78%), 65 estaban vacíos (15,9%), 14 contenían huesos de peces digeridos y sin identificar (3,4%), seis contenían diversas piezas de plástico (1,5%), cuatro contenían algas flotantes (1,0%) y uno contenía un anzuelo (0,2%). Para lograr una ordenación sostenible de una pesquería, es necesario conocer la conexión entre las tasas de consumo alimentarias y los niveles tróficos de los grandes predadores para deducir la importancia de los principales predadores y pescadores en la pesquería.

KEYWORDS

Feeding habits, Mahi mahi*, South Atlantic, Diet*

Introduction

The dolphinfish, *Coryphaena hippurus* is a highly migratory species with worldwide occurrence in tropical and subtropical waters with temperatures above 21° C. In Brazil, the genus *Coryphaena* is represented by two species: *C. hippurus* and the rare species *C. equiselis* (Zavala-Camim, 1986; Lessa *et al.* 2009). The occurrence of *C. equiselis* in southeastern and southern Brazil was based on individuals collected in stomach contents of tunas (Zavala-Camim, 1986). In the northern and northeastern coast, its occurrence was recorded during the REVIZEE program by Lessa *et al.* (2009).

From the ecological perspective, the dolphinfish plays an important role, since it is a highly pelagic fish species, located at the top portion of the food chain, contributing to the balance of the marine ecosystem. However, this species is also caught accidently by different fishing gear, commercial and sports, especially tuna longliners (*Thunnus* spp.) and swordfish (*Xiphias glaudius*).

The dolphinfish is caught mainly by multispecific small size fleet (Itaipava fleet) and it is one of their major targets off the southern coast in Brazil. Sports fishing using rod and reel catch this species off the coast in Rio de Janeiro, Sao Paulo and Espirito Santo States during recreational tournaments (Paiva and Pires-Junior, 1983; Arfelli *et al*., 1994; Amorim and Silva, 2005).

This study analyzed stomach contents of *C. hippurus*, caught in southern Brazil, considering species composition and relative occurrence of food items.

Materials and Methods

We sampled 409 *Coryphaena hippurus* stomachs from September 2003 to March 2009, 343 stomachs (83.8%) were obtained from fish caught on water surface by longline small size fleet and 66 (16.2%) from oceanic sports fishing tournaments the “Iate Clube do Rio de Janeiro-ICRJ” and the “Costa Azul Iate Clube-CAIC”. In this study, stomachs were sampled off the northern coast of Rio de Janeiro State, Brazil (22ºS to 24ºS and 40°W to 44°W) **Figure 1**.

The fish were gutted at landing to separate stomach contents, which were kept in 10% formalin for later laboratorial analys. The identification of stomach contents was carried out according to Figueiredo (1978), FAO (1978, 1994, 1999); Figueiredo and Menezes (1978, 1980); Menezes and Figueiredo (1980, 1985); Zavala-Camin, (1981, 1982, 1986, 1987).

Quantitative analyses were performed to identify the dominant, abundant, average, scarce and rare occurrence using the methods of Numerical Frequency (NF) in percentage and Relative Abundance (RA), as follow: dominant (> 15%), abundant (7-15%), average (1-6.9%) scarce (0.1-0.9%) and rare (> 0.1%). We carried out a quantitative analysis to identify the main species, secondary and companion species by determining the Numerical Frequency (NF) in % and Relative Abundance (RA).

Results

Of the total of 409 stomachs examined, 319 contained food (78.0%), 65 stomachs were empty (15.9%), 14 stomachs contained digested and not identified fish bones (3.4%), six stomachs contained various plastic pieces (13 small pieces) (1.5%), four stomachs contained floating algae (1.0%) and one stomach contained a hook (0.2%), totaling 90 stomachs (22%) with atypical contents of the fish diet.

The *Sardinella brasiliensis* and *Hemiramplus brasiliensis* was not computed in the analysis of stomach contents because they were used as bait. The 147 stomachs contained *Sardinella brasiliensis* with a total of 262 units and nine stomachs contained *Hemiramplus brasiliensis* totaling 12 units.

According to 196 stomachs, 41 stomachs contained *Trichiurus lepturus* (20.9%), 31 stomachs contained *Loligo* sp totaling 43 units (15.8%), 20 stomachs contained *Selar crumenophthalmus* (10.2%), 17 stomachs contained *Decapterus punctatus* (8.7%), 16 contained *Exocoetus volitans* totaling 34 units (8.2%), 11 contained *Cyclichthys spinosus* (5.6%), eight contained *Auxis thazard thazard* totaling nine units (4.1%), six contained *Tylosurus acus acus* totaling seven units (3.1%), six contained *Argonauta nodosa* totaling 16 units (3.1%), four contained *Lagocephalus laevigatus* (2.0%), four contained *Dactylopterus volitans* (2.0%), four contained *Paratrachichthys atlanticus* totaling 39 units (2.0%), four contained floating algae (2.0%), three contained *Opisthonema oglium* totaling five units (1.5%), three contained *Peprilus paru* (1.5%), three contained *Stephanolepis hispidus* totaling six units (1.5%), two stomachs contained *Lactophrys* sp totaling three units (1.0%), two contained *Decapterus macarellus* (1.0%), two contained *Priacanthus arenatus* totaling four units (1.0%), two contained marine shrimp (1.0%), one contained *Scomber colias* (0.5%), one contained *Acanthurus chirurgus* totaling 40 units (0.5%), one stomach contained *Diaphus dumerilii* (0.5%), one contained *Decapterus tabl* (0.5%), one contained *Pomatomus saltator* (0.5%) and one stomach contained a crab (0.5%) observed in **Table 1**.

Discussion

Several stomachs contained more than one shrimp specimen from the same or different species in their content. The specimens were identified and counted by species, determining the fish feeding preference in all stomachs examined. We observed the large number of individuals of the same species in two distinct stomachs, one containing 40 individuals of *Acanthurus chirurgus* and another 39 individuals of *Paratrachichthys atlanticus*.

Several specimens identified were in juvenile stage of development, such as *Trichiurus lepturus*, *Lagocephalus laevigatus*, *Stephanolepis hispidus*, *Lactophrys* sp, *Pomatomus saltator*, *Cyclichthys spinosus*, *Peprilus paru* and *Arenatus arenatus*.

Sardinella brasiliensis is the main feeding source of *Coryphaena hippurus* (NF 35.9% and RA = dominant). The study site is one of the most representative for the occurrence and capture of *Sardinella brasiliensis* in Brazil, which is also considered the main bait used by operant extractivist fleet of surface. *Hemiramplus brasiliensi*, on the other hand, is the main bait used by ocean fishing boats to catch sailfish, corroborating the fact the five of the 12 specimens (*Hemiramplus brasiliensis*) were found with a hook device, which consists of a bait arrangement used by sports fishermen to maximize catches in fishing tournaments promoted by the abovementioned fishing clubs.

The six stomachs containing 13 small plastic pieces added to four stomachs containing floating algae and one stomach containing a crab are associated with *the accumulation lines*, another important food source, when *Coryphaena hippurus* visit tangles on the edge of ocean currents for nibbling floating algae and end up eating garbage disposed from boats and ships. These *accumulation lines* serve as a shelter for countless juveniles and decapode crustaceans, complementing their diet.

The significant increase in the number of offshore oil platforms has aggravated the situation once they are located close to the slope edge and in deep waters, adding a new component to the scenario described in the study site (Carneiro *et al.*, 2000). These platforms create a shelter for juveniles of a number of species serving as food source for oceanic pelagic species that regularly visit the offshore structures to find food, which explains the high occurrence of juvenile specimens in the stomach contents of *Coryphaena hippurus*.

The occurrence of squid specimens (*Loligo* sp) in 31 stomachs and marine octopus (*Argonauta nodosa*) in six stomachs, totaling 37 stomachs with occurrence of mollusks, has already been registered in the stomachs of other oceanic species in the same area (Pimenta *et al.*, 2004). Squids dwell in deep waters and come to surface for reproductive needs, when they become another important food source for *Coryphaena hippurus*. The sum of the mollusks (squid, 15.8% and octopus, 3.1%) represent 18.9% of *Coryphaena hippurus* diet (**Table 1**).

Trichiurus lepturus (NF 20.9% and RA = abundant) presents itself as the only main species in *Coryphaena hippurus* diet, *Loligo* (Nf 15.8% and RA Abundant), *Selar crumenophthalmus* (NF 10.2% and RA = medium), *Decapterus punctatus* (NF 8.7% and RA = medium), *Exocoetus volitans* (NF 8.2% and RA = medium), *Cyclichthys spinosus* (NF 5.6% AR = medium), *Auxis thazard thazard* (NF 4.1% and RA = medium), *Tylosurus accuses cus* (NF 3.1% and RA = medium) and *Argonauta nodosa* (NF 3.1% and RA = medium) present themselves as secondary species of *Coryphaena hippurus* diet (**Table 1**).

Lagocephalus laevigatus (NF 2.0% and RA = rare), *Dactylopterus volitans* (NF 2.0% and RA = rare), *Opisthonema oglium* (NF 1.5% and RA = rare), *Paratrachichthys atlanticus* (NF 1.5% and RA = rare), *Peprilus paru* (NF 1.5% and RA = rare), *Stephanolepis hispidus* (NF 1.5% and RA = rare), *Lactophrys sp* (NF 1.0% and RA = rare), *Decapterus macarellus* (NF 1.0% and RA = rare), *Priacanthus arenatus* (NF 1.0% and RA = rare), *Scomber colias* (NF 0.5% and RA = rare), *Acanthurus chirurgus* (NF 0.5% and RA = rare), *Diaphus dumerilii* (NF 0.5% and RA = rare), *Decapterus tabl* (NF 0.5% and RA = rare) and *Pomatomus saltator* (NF 0.5% and RA = rare) present themselves as companion species of *Coryphaena hippurus* diet (**Table 1**).

Empty stomachs had NF 15.8% and RA relatively abundant. Digested fish bones, mainly vertebrae and some head bony plates had NF 3.4% and RA medium. Small plastic pieces in stomachs had NF 3.1% RA medium.

Floating algae in stomachs associated with *accumulation lines* on the edges of ocean currents had NF 2.0% and RA rare. The only crab occurrence (NF 0.5% and RA rare) in stomach contents is associated with *the accumulation lines* represented by tangles on the edge of ocean currents composed of floating algae and garbage disposed from boats and ships, which also houses juvenile specimens similarly to the structure of offshore oil platforms. The two stomachs with marine shrimp had NF 1.0% and RA rare.

The bait slice, probably from Scombridae, with knife-precision cut, had NF 1.0% and RA rare. The hook found in one stomach, which is used as a catch device, had NF 0.5% and RA rare.

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Table 1. Numerical Frequency in percentage and Relative Abundance of stomach content: dominant (DO), abundant (AB), average (AV) scarce (SC) and rare (RR) of *Coryphaena hippurus*.

No.	***Species***	***Numerical Frequency %***	***Relative Abundance***
41	*Trichiurus lepturus*	20,9	DO
31	*Loligo sp*	15,8	DO
20	*Selar crumenophthalmus*	10,2	AB
17	*Decapterus punctatus*	8,7	AB
16	*Exocoetus volitans*	8,2	AB
11	*Cyclichthys spinosus*	5,6	AV
8	*Auxis thazard thazard*	4,1	AV
6	*Tylosurus acus acus*	3,1	AV
6	*Argonauta nodosa*	3,1	AV
4	*Lagocephalus laevigatus*	2,0	AV
4	*Dactylopterus volitans*	2,0	AV
4	Floating algae	2,0	AV
4	*Paratrachichthys atlanticus*	2,0	AV
3	*Opisthonema oglium*	1,5	AV
3	*Peprilus paru*	1,5	AV
3	*Stephanolepis hispidus*	1,5	AV
2	*Lactophrys sp*	1,0	AV
2	*Decapterus macarellus*	1,0	AV
2	*Priacanthus arenatus*	1,0	AV
2	Camarões oceânicos	1,0	AV
1	*Scomber colias*	0,5	SC
1	*Acanthurus chirurgus*	0,5	SC
1	*Diaphus dumerilii*	0,5	SC
1	*Decapterus tabl*	0,5	SC
1	*Pomatomus saltator*	0,5	SC
1	Crab	0,5	SC

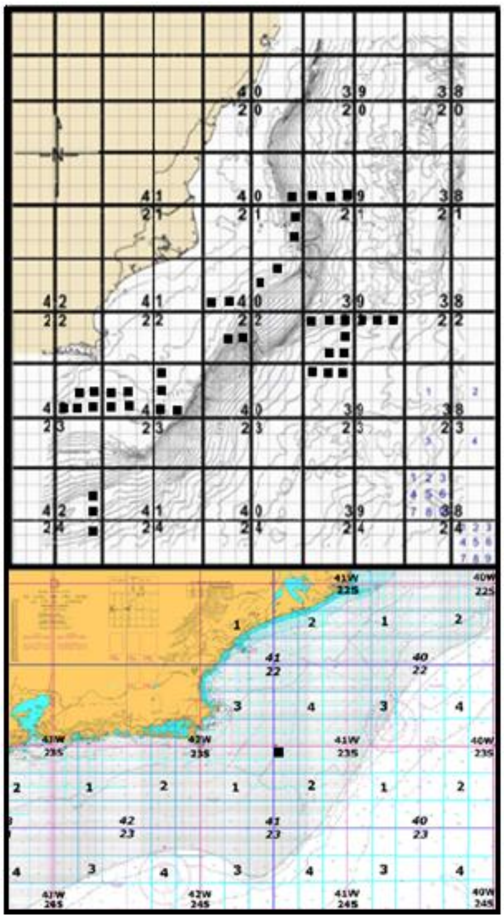

Figure 1. Fishery area off northern coast of Rio de Janeiro State, Brazil.